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Blood Pressure Differences Between Northern and Southern Chinese: Role of Dietary Factors:

The International Study on Macronutrients and Blood Pressure

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Abstract

Blood pressure and prevalence of high blood pressure are greater for northern than southern Chinese. Reasons for these differences are unclear. Relationships of north–south blood pressure differences with multiple dietary factors were investigated in 839 Chinese participants, International Study on Macronutrients and Blood Pressure (INTERMAP), 561 northern, 278 southern, aged 40 to 59 years. Daily nutrient intakes were determined from four 24-hour dietary recalls and 2 timed 24-hour urine collections. Average systolic/diastolic pressure levels were 7.4/6.9 mm Hg higher for northern than southern participants. Southern participants had lower body mass index, sodium intake, sodium/potassium ratio, and higher intake of calcium, magnesium, phosphorus, and vitamins A and C. Considered singly, with control for age and gender, several dietary variables (eg, body mass index, urinary sodium/potassium ratio, urinary sodium, dietary phosphorus, and magnesium) reduced north–south blood pressure differences by ≥10%. Controlled for age and gender, nondietary variables had little effect on north–south blood pressure differences. With inclusion in regression models of multiple dietary variables (sodium, potassium, magnesium or phosphorus, body mass index), north–south blood pressure differences became much smaller (systolic −1.1, diastolic 1.6 mm Hg) and statistically nonsignificant. In conclusion, multiple dietary factors accounted importantly for north–south blood pressure differences. Efforts are needed to improve nutrition in China, especially in the north, as well as in other populations including those in the United States, for prevention and control of adverse blood pressure levels and major adult cardiovascular disease.

Keywords

blood pressure; diet; population

Hypertension is more common in northern than southern Chinese, and average blood pressure (BP) levels, both systolic BP (SBP) and diastolic BP (DBP), are higher in the north than in the south.[1–7] For example, prevalence of hypertension was 34% in the north and 23% in the south, and average SBP/DBP levels were 127.7/80.6 mmHg in the north, which is 5.0/3.0 mm Hg higher than that in the south among people aged 35 to 74 from 2000 to 2001.[7] Reasons for these differences are not clear. Data from a few studies suggest that heavier body mass and higher salt intake in the north may partially explain these differences.[8–11]

In this study, we used data from the International Study on Macronutrients and Blood Pressure (INTERMAP) to examine north–south BP differences in China and to assess nutritional factors that may be responsible.

Methods

INTERMAP is an international cooperative study on relations of multiple dietary factors to BP among 4680 participants aged 40 to 59 from 17 diverse population samples in China, Japan, United Kingdom, and United States. We used 2 Chinese samples from the north (Beijing, Shanxi; n=561) and 1 from the south (Guangxi; n=278).

INTERMAP design, methods, and quality-control procedures have been reported in detail.[12–14] A brief description is given here.

Study Samples

Chinese samples were from rural populations: 2 north (Pinggu County, Beijing, and Yu County, Shanxi Province), and 1 south (Wuming County, Guangxi Zhuang Autonomous Region). In accordance with the INTERMAP Protocol,[12] a population-based sample of 260 persons (1 per family) was randomly selected from each target population, stratified by gender and 10-year age group (ie, 65 persons in each of 4 10-year age-gender groups).

Field work was conducted from September 1997 to January 1998. Each participant attended the local INTERMAP center on 4 occasions: 2 pairs of consecutive days ≈3 to 6 weeks apart. All data were collected by trained and certified staff.

Data Acquisition

Blood pressure measurement protocol was the same as in INTERSALT Study,[15] ie, participant was seated quietly for at least 5 minutes and BP was measured twice with a random zero sphygmomanometer at each of the 4 visits. Height and weight without shoes or heavy clothes were measured at first and third visits. Data were collected by interviewer-administered questionnaire about age, education, occupation, work and leisure physical activity, smoking history, previous medical history, and medication use.

Two timed 24-hour urine specimens were collected. Collections were started at the research center on the first and third visits and completed at the center the next day. Urine aliquots were stored frozen at −20°C and then air-freighted frozen to the Central Laboratory (Leuven, Belgium), where urinary sodium (Na), potassium (K), urea, and other levels were measured with rigorous internal and external quality control.

Dietary data were collected at each visit by standardized 24-hour dietary recalls. All food and drink consumed in the previous 24 hours were recorded by trained and certified interviewers. Daily alcohol consumption during the previous 7 days was also recorded at the first and third visits. Interviewers coded dietary data on survey day according to the Chinese Coding Manual (China Addendum to the INTERMAP *Nutrition Manual of Operations*). Extensive efforts were made to obtain high-quality dietary data.[12–14] Nutrients were calculated from foods with use of an extensive database derived from the Chinese national food table[16] and enhanced by the Nutrition Coordinating Center (NCC), University of Minnesota, working cooperatively with Chinese INTERMAP colleagues.[12–14]

Statistical Methods

Dietary data here are expressed as nutrient densities, ie, percent total kilocalories for nutrients supplying energy (kcal from nutrient/total kcal)×100; for other nutrients per 1000 kcal (amount per day/total kcal)×1000.

Measurements for each individual were averaged across visits. Because average BP, dietary, and nondietary variables were generally similar for Beijing and Shanxi samples,[17] analyses data not only were used for these 2 samples separately but also were combined as the “north” sample; the Guangxi sample was the “south” sample.

For descriptive statistics, means and standard deviations or percentages are given for each sample and for the north sample, with *t* tests or χ^2 tests for north–south comparisons. Tests were also performed between the 2 north samples. Based on significant north–south differences for nondietary and dietary variables, multiple linear regression models were used to examine relations of dietary factors with north–south differences in SBP and DBP with control for nondietary variables. The basic model (model 1) included age, gender, and an indicator for north to obtain the age–gender-adjusted coefficient for north–south SBP and DBP differences. Then each factor was added to model 1 separately, and percentage reduction from the model 1 coefficient was calculated to assess influence of the added variable on north–south BP differences. In addition to age and gender, model 2 also included nondietary factors. Finally, dietary variables were included in combinations to assess their joint impact on north–south BP differences. Three groups of nutrients were added to model 2: 24-hour urinary Na and K,[18] and electrolytes plus magnesium or phosphorus (magnesium and phosphorus were highly correlated, r=0.88; hence, these 2 were added separately). These models were computed without or with inclusion of body mass index (BMI), because nutrient-BP relations may be overadjusted with BMI in the models because of associations of nutrient intake with body mass and body mass with BP;[19] also, BMI, a variable measured with high intraindividual reproducibility, may distort coefficients for nutrient–BP relations because nutrients are measured with lower reproducibility.[20] Interactions between BMI and single nutrients in influencing BP were also assessed. Analyses were also repeated with exclusion of participants using antihypertensive medication.

Results

Descriptive Statistics

Beijing and Shanxi participants had generally similar average SBP and DBP levels, but they were higher for Beijing and Shanxi combined (north) than those for Guangxi (south) by 7.4 and 6.9 mm Hg (Table 1). Percent on antihypertensive medication was higher for the north (10.2%) than south (2.2%). Hypertension (SBP ≥140, DBP ≥90, or using medication) prevalence was higher for the north (22.3%) than south (7.2%).

Average age and years of education were similar for north and south (Table 1). Mean BMI was 23.8 kg/m^2 for the north, which was 2 U higher than for the South (P<0.001). Southern participants engaged, on average, in 4 hours of heavy physical activity per day. Northern participants performed <1 hour of heavy physical activity per day (*P*<0.001). Percentage reporting consumption of a special diet was higher for north than south, as was the proportion with history of cardiovascular disease/diabetes. Percent of current drinkers was lower for north, especially in Shanxi, as was alcohol intake.

For most nutrient variables, mean intakes by Beijing and Shanxi participants were similar, and different from Guangxi (Table 1). With absolute differences in most nutrient variables between Beijing and Shanxi being small, it was deemed valid to combine Beijing and Shanxi as the “north” sample. Southern participants reported slightly lower average total energy intakes, higher total and animal protein (%kcal) intakes, higher total fat, saturated fat, and monounsaturated fat intakes, higher Keys dietary lipid score, lower polyunsaturated/saturated fatty acids ratio (PFA/SFA), and relatively less carbohydrate, starch, and dietary fiber intake than northern participants. Southern intakes of vitamin A, retinol, beta-carotene, vitamin C, calcium, magnesium, and phosphorus were higher; vitamin E and selenium intakes were lower. Na and Na/K intakes were ≈50% lower, and K excretion was higher for the south.

Relation of Single Dietary Variables to North–south SBP/DBP Differences

With adjustment for age and gender in multiple regression analyses, north SBPs/DBPs were higher than those for south by 7.6/6.9 mmHg (*P*<0.001; Table 2; model 1). These coefficients were altered only slightly by inclusion in the model separately (one at a time) of 4 nonnutrient variables (data not shown). In contrast, with BMI in the model, north–south BP differences were reduced 36.2% (SBP) and 26.5% (DBP) (row B, Table 2). Among nutrients, urinary Na/K ratio produced the largest reduction in SBP coefficient (−56.3%), then phosphorus (−49.0%) (rows D and G, Table 2). Several other nutrients reduced site SBP coefficients by 10% or more, eg, urinary Na, dietary calcium, and magnesium. North–south DBP differences were sizably reduced by phosphorus (−43.7%), magnesium (−28.4%), urinary Na/K (−25.9%), and urinary Na (−20.2%)

Results were similar with exclusion of participants using antihypertensive medication (data not shown). In analyses of BMI–nutrient interactions in relation to SBP and DBP, no significant interaction was found (data not shown).

Relation of Combinations of Dietary Variables to North–south SBP/DBP Differences

Compared with model 1, additional adjustment for cardiovascular disease/diabetes diagnosis, special diet, and hours of heavy physical activity together had little effect on north–south SBP/DBP differences (Table 3). Inclusion of BMI reduced the coefficients sizably (eg, in model 2, by 30% and 21%).

Urinary Na and K greatly reduced north–south SBP difference by 66.3% without BMI and 77.7% with BMI to statistically nonsignificant levels (model 3, Table 3). The combinations of urinary Na, K, magnesium, or phosphorus (models 4 and 5) further reduced north–south SBP difference to 2 mm Hg or less (statistically nonsignificant). Results for DBP were similar but quantitatively less. In these 3-nutrient models, effect of adding BMI was modest compared with its large effect without the nutrients (models 1 and 2). With exclusion of participants on antihypertensive medication, results were similar (data not shown).

Discussion

Main findings of this study are: (1) northern Chinese had significantly higher SBP/DBP (7.4/6.9 mm Hg higher) than southern Chinese; (2) southerners generally had healthier lifestyles than Northerners, ie, lower BMI, Na, Na/K intake, higher physical activity, and micronutrient intake; (3) inclusion in multiple linear regression models of several dietary variables, Na, K, phosphorus, or magnesium and BMI, virtually eliminated north–south BP differences.

Differences in BP levels and prevalence of hypertension between northern and southern Chinese have been reported.[1–7] Few studies explored reasons for these differences. In the PRC-USA Collaborative Study,[8] BP levels were markedly higher in northern than southern participants, for men and women, and for urban and rural. Differences in BMI (higher for north), alcohol intake, and other (nondietary) factors only partially explained BP differences. Nutrient influences were not reported.

Previous studies documented much higher salt and Na/K intake for north than south.[5–7,10,21] High Na and Na/K intake adversely influence BP levels.[5,6] In the INTERSALT Study, compared with 45 other samples worldwide, the Chinese mean BMI was lower and heavy drinking was less, but Chinese Na and Na/K intakes were higher, and upward slope of BP with age was greater than for other samples.[11] These findings suggest that dietary Na and Na/K are important in explaining regional BP differences in China, but no previous studies have quantified this relation. Our findings support this inference; northern Na and Na/K intakes were significantly and substantially higher and accounted sizably for higher northern BP levels.

Our findings also confirm that even modest BMI differences within the nonoverweight range influence BP, per extensive data on the BMI-BP relation.[22] They further indicate that other dietary factors account importantly for north–south BP differences, particularly higher southern intake of magnesium and phosphorus. The importance of dietary factors in explaining intergroup BP differences has been demonstrated in other studies. Among 2195 US INTERMAP participants, there was a significant inverse relation between years of education and BP, reduced to statistically nonsignificant levels with inclusion in linear regression models of Na, K, alcohol, vegetable protein, Keys dietary lipid score, magnesium, calcium, phosphorus, and iron.[23]

The importance of dietary influences on BP is also supported by data from clinical trials. The Dietary Approaches to Stop Hypertension (DASH) trial showed that feeding a “combination” diet high in fruits, vegetables, legumes, nuts, low-fat dairy products, and reduced in fatty meats, fats, and sweets lowered BP levels in prehypertensive and hypertensive individuals.[24] In a subsequent trial, reduction in Na intake augmented this effect of the DASH diet on BP.[25] The DASH trials were not designed to evaluate impact of specific nutrients on BP, but it is noteworthy that the DASH diet is higher in potassium, calcium, magnesium, phosphorus, vitamins, fiber, PFA/SFA, protein, and lower in Na, Na/K, total fat, saturated fat, cholesterol, and sugar.

Geographic variations in BP are also apparent in other countries. For example, in the southern US BP levels and prevalence of hypertension are higher than in the north.[26,27] The southeast region of the US also has higher stroke mortality ("stroke belt").[28] Dietary differences between the south and north could partially account for such differences. The National Health and Nutritional Examination Survey III showed that the southern region had higher consumption of Na, cholesterol, monounsaturated fat, and lower consumption of K, calcium, phosphorus, magnesium, copper, fiber, and vitamins than other regions.[27]

Main strengths of the present study are: (1) population-based samples; (2) standardized collection of high-quality BP and nutrition data; (3) use of improved nutrient database; and (4) multiple quality-control procedures. The study is limited by small sample size (3 rural samples) and its cross-sectional design. Nevertheless, significant dietary differences between north and south were observed that accounted for north–south BP differences. The findings may or may not be generalizable to all northern and southern Chinese and to other populations. However, their concordance with other research findings, especially extensive data on adverse influences on BP of higher Na and Na/K intakes and higher BMI, is consistent with the possibility that they are generalizable.

In conclusion, INTERMAP data from middle-aged Chinese participants from the north and the south showed that southerners had much lower BP levels and generally more favorable lifestyles, especially lower BMI, Na intake, Na/K ratio, and higher intake of magnesium and phosphorus (also other micronutrients). These largely accounted for their lower BP levels. Compared with northern Chinese, the nutrient intake of southern Chinese more closely resembles the DASH–sodium combination diet, demonstrated to reduce BP levels significantly in prehypertensive and hypertensive individuals.

Perspectives

Substantial increases in SBP/DBP from youth through middle age, high prevalence rates of prehypertension and hypertension, and low prevalence rates of normotension are common phenomena worldwide. Hence, adverse BP level, which is an established major risk factor for epidemic adult cardiovascular disease, is a virtually population-wide problem, but southern Chinese are significantly less affected. Geographic variations in BP are present in many countries, including the United States. The data here show that dietary differences account substantially for lower BP in southern Chinese. These findings may well have important public health implications, not only for China but also for other countries. In addition to the known importance of maintaining an optimal body weight and lower salt intake, higher intake of specific micronutrients may be valuable to improve population BP levels and prevent cardiovascular disease.

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TABLE 1.

Descriptive Statistics, Mean, or Prevalence (%) by Sample and Region

Variable	Beijing (North)	Shanxi (North)	North	Guangxi (South)
Number of participants	272	289	561	278
SBP, mm Hg	122.4±17.8 *	124.9±18.9 †	123.7±18.4 ‡	116.3±14.1
DBP, mm Hg	76.5±9.8 *§	74.5±10.9 †	75.5±10.4 ‡	68.6±8.0
Male, %	48.9	49.5	49.2	50.4
Age, y	49.1±5.8	48.7±5.9	48.9±5.8	49.1±5.7
Education, y	5.5±3.3	5.2±2.6	5.3±3.0	5.5±2.7
BMI, kg/m^2	23.8±3.3 *	23.7±3.6 †	23.8±3.5 ‡	21.8±2.6
Heavy physical activity, h/d	1.2±3.1 *§	0.6±1.6 †	0.9±2.4 ‡	4.0±4.0
Special diet, %	6.3 *	8.7 †	7.5 ‡	1.1
CVD-DM diagnosis, %	9.2 *	10.0 †	9.6 ‡	1.8
Current drinker, %	48.5 §	37.7 †	43.0 ‡	50.7
Alcohol, all, g/day ¶	9.5±21.3 §	5.4±16.1 †	7.4±18.9 ‡	11.1±25.5
Alcohol, drinkers only, g/d ¶	19.6±27.2	14.3±23.7 †	17.2±25.7	21.9±32.4
Energy, kcal/d	2164±624 *§	1996±546	2078±590 ‡	1956±542
Total protein, %kcal	12.0±1.4 *§	11.5±1.4 †	11.8±1.4 ‡	13.8±2.1
Animal protein, %kcal	1.7±1.6 *§	1.2±1.4 †	1.5±1.6 ‡	4.5±2.5
Vegetable protein, %kcal	10.3±1.2 *	10.3±1.0 †	10.3±1.1 ‡	9.3±1.3
Total fat, %kcal	19.9±6.1 *§	17.6±5.4 †	18.8±5.8 ‡	22.4±5.9
SFA, %kcal	4.7±1.9 *§	4.3±1.9 †	4.5±4.5 ‡	6.1±2.0
MFA, %kcal	7.3±2.8 *	7.7±2.7 †	7.5±2.8 ‡	9.1±2.6
PFA, %kcal	6.9±2.4 *§	4.7±1.4 †	5.8±2.2	5.9±2.1
Ratio, PFA/SFA	1.7±0.7 *§	1.3±0.4 †	1.5±0.6 ‡	1.1±0.4
Cholesterol, mg/1000 kcal	91.5±84.7	81.6±104.1	86.4±95.2	94.0±62.7
Keys dietary lipid score	16.0±10.1 *	15.9±11.4 †	15.9±10.7 ‡	22.1±8.3
Total available carbohydrate, %kcal	65.5±9.1 *§	69.2±7.7 †	67.4±8.6 ‡	60.2±10.8

Variable	Beijing (North)	Shanxi (North)	North	Guangxi (South)
Starch, %kcal	56.9±9.1 *§	60.7±8.2 †	58.8±8.8 ‡	51.6±11.3
Total dietary fiber, g/1000 kcal	13.6±3.0 §	15.2±3.7 †	14.4±3.5 ‡	13.8±4.3
Estimated total sugar, %kcal	8.6±4.2	8.5±4.2	8.5±4.2	8.6±6.9
Alcohol, %kcal	2.7±5.7 §	1.6±4.7 †	2.1±5.2 ‡	3.5±7.7
Vitamin A, IU/1000 kcal	1706±1208 *§	1405±847 †	1551±1048 ‡	3606±2171
Retinol, μg/1000 kcal	36.5±40.3 *	33.0±55.6 †	34.7±48.8 ‡	73.3±115.1
Beta-carotene, μg/1000 kcal	950±723 *§	777±489 †	861±619 ‡	2016±1325
Vitamin C, mg/1000 kcal	41.6±18.1 *§	32.2±15.7 †	36.8±17.5 ‡	45.0±21.9
Total vitamin E, mg ATE/1000 kcal	6.0±1.7 *§	5.1±1.2	5.5±1.6 ‡	4.9±1.6
Calcium, mg/1000 kcal	153±50 *§	124±41 †	138±48 ‡	176±62
Magnesium, mg/1000 kcal	110±22 *§	157±37 †	134±39 ‡	198±28
Iron, mg/1000 kcal	7.7±1.6	7.9±1.2	7.8±1.4	7.8±2.2
Phosphorus, mg/1000 kcal	347±65 *§	408±73 †	378±76 ‡	562±67
Selenium, μg/1000 kcal	18.2±3.6 *§	16.9±4.1 †	17.5±3.9 ‡	14.7±4.4
Urinary sodium, mmol/24 h	275±90 *	268±85 †	271±88 ‡	139±57
Urinary potassium, mmol/24 h	37.0±11.8 *	37.1±11.2 †	37.1±11.5 ‡	40.6±14.7
Ratio, urinary Na/K, mmol/mmol	7.8±2.5 *	7.5±2.3 †	7.6±2.4 ‡	3.7±1.5

North indicates Beijing and Shanxi samples combined; heavy physical activity: h/d of heavy activity, work, and leisure; special diet: weight loss, weight gain, vegetarian, salt-reduced, diabetic, fat-modified or other; CVD-DM diagnosis: history of heart attack, other heart disease, stroke, or diabetes; all nutrients are from 4 24-hour dietary recalls/person.

SFA indicates saturated fatty acids; MFA, monounsaturated fatty acids; PFA, polyunsaturated fatty acids. Keys dietary lipid score: 1.35 (2SFA-PFA)+1.5CHOL$^{1/2}$, where SFA, PFA, and CHOL (cholesterol) are as defined above; total available carbohydrate, exclusive of dietary fiber; estimated total sugar, total available carbohydrate–starch; ATE, α-tocopherol equivalents.

Values are mean±SD unless otherwise noted.

* $P<0.05$ for Beijing vs south (*t* test or χ^2 test).

† $P<0.05$ for Shanxi vs south (*t* test or χ^2 test).

‡ $P<0.05$ for north vs south (*t* test or χ^2 test).

§ $P<0.05$ for Beijing vs Shanxi (*t* test or χ^2 test).

¶ From 2 7-day questionnaires.

TABLE 2.

Relation of Variables Considered Singly to North–South SBP/DBP Differences

Row	Variables in Multiple Linear Regression Model	SBP	DBP
A	Model 1: site (north/south), age, gender	7.5516* (<0.001)†	6.9417 (<0.001)
B	Model 1+BMI, kg/m^2	4.8209 (<0.001) −36.2%‡	5.1056 (<0.001) −26.5%
C	Model 1+urinary Na, mmol/24 h	5.0659 (<0.001) −32.9%	5.5424 (<0.001) −20.2%
D	Model 1+urinary Na/K, mmol/mmol	3.2998 (0.04) −56.3%	5.1424 (<0.001) −25.9%
E	Model 1+calcium, mg/1000 kcal	6.7671 (<0.001) −10.4%	6.7503 (<0.001) −2.8%
F	Model 1+magnesium, mg/1000 kcal	6.6704 (<0.001) −11.7%	4.9704 (<0.001) −28.4%
G	Model 1+phosphorus, mg/1000 kcal	3.8497 (<0.001) −49.0%	3.9104 (<0.001) −43.7%
H	Model 1+selenium, μg/1000 kcal	8.2406 (<0.001) +9.1%	7.0297 (<0.001) +1.3%
I	Model 1+total protein, %kcal	6.9189 (<0.001) −8.4%	6.9176 (<0.001) −0.3%
J	Model 1+animal protein, %kcal	7.4379 (<0.001) −1.5%	7.3910 (<0.001) +6.5%
K	Model 1+vegetable protein, %kcal	8.0542 (<0.001) +6.7%	7.3447 (<0.001) +5.8%
L	Model 1+total fat, %kcal	6.9892 (<0.001) −7.4%	6.8965 (<0.001) −0.7%
M	Model 1+SFA, %kcal	6.6900 (<0.001) −11.4%	6.9887 (<0.001) +0.7%
N	Model 1+MFA, %kcal	7.1693 (<0.001) −5.1%	6.7261 (<0.001) −3.1%
O	Model 1+ratio, PFA/SFA	7.1370 (<0.001) −5.5%	6.7785 (<0.001) −2.4%
P	Model 1+Keys dietary lipid score	7.1066 (<0.001) −5.9%	6.8739 (<0.001) −1.0%
Q	Model 1+starch, %kcal	7.6734 (<0.001) +1.6%	7.3004 (<0.001) +5.2%
R	Model 1+vitamin C, mg/1000 kcal	7.0383 (<0.001) −6.8%	6.8748 (<0.001) −1.0%

*Coefficient for difference in BP (mm Hg) between north and south.

†*P* value.

‡Percent reduction in site–BP coefficient compared to model 1.

Detailed data not shown for variables influencing BP coefficient <5.0%: CVD/diabetes diagnosis, consumption of special diet, education, heavy physical activity, energy, urinary K, alcohol, PFA, cholesterol, total available carbohydrate, fiber, vitamin A, beta-carotene, and total vitamin E.

TABLE 3.

Relation of Combinations of Dietary Variables to North–South SBP/DBP Differences

Model	Variables in Multiple Linear Regression Model	SBP Without BMI	SBP With BMI	DBP Without BMI	DBP With BMI
1	Site (north/south), age, gender	7.5516* (<0.001)	4.8209 (<0.001)† −36.2%‡	6.9417* (<0.001)	5.1056 (<0.001)† −26.5%‡
2	Model 1+CVD disease/diabetes diagnosis, special diet, hours of heavy physical activity	7.0950 (<0.001) −6.0%‡	4.9872 (<0.001) −29.7%§	6.8130 (<0.001) −1.9%‡	5.3654 (<0.001) −21.2%§
3	Model 2+24-h urinary Na, 24-h urinary K	2.3889 (0.19) −66.3%§	1.5846 (0.37) −77.7%§	4.5943 (<0.001) −32.6%§	4.0377 (<0.001) −40.7%§
4	Model 2+model 3 (24-h urinary Na, 24-h urinary K)+magnesium	1.9756 (0.34) −72.2%§	1.3707 (0.49) −80.7%§	2.8831 (0.017) −57.7%§	2.4678 (0.032) −63.8%§
5	Model 2+model 3 (24-h urinary Na, 24-h urinary K)+phosphorus	−0.9001 (0.70) −112.7%§	−1.0913 (0.62) −115.4%§	1.7422 (0.20) −74.4%§	1.6104 (0.21) −76.4%§

Variable definition and units in Tables 1 and 2.

*Coefficient for SBP or DBP difference (mm Hg) between north and south.

†*P* value.

‡Percent reduction in site (north–south)–SBP/DBP coefficient compared to model 1 without BMI.

§Percent reduction in site (north–south)–SBP/DBP coefficient compared to model 2 without BMI.