Original Article

Fruit and Vegetable Consumption and the Risk of Hypertension Determined by Self Measurement of Blood Pressure at Home: The Ohasama Study

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It is well recognized that high fruit and vegetable consumption is associated with a reduction of blood pressure (BP) measured by conventional BP measurement in Western countries; however, there is little evidence about these associations in other regions and there have been no reports on these associations using self-measured BP at home (home BP). The objective of this work was to investigate the associations of fruit and vegetable consumption and their related micronutrients with the reduction of hypertension risk by using home BP in Japanese residents. Data were obtained from 1,569 residents aged 35 and over who measured their home BP in a general population of Ohasama, Japan. Dietary intake was measured using a 141-item food-frequency questionnaire (FFQ) and then subjects were divided into tertiles according to fruit, vegetable, potassium, vitamin C, and *β*-carotene consumption. Hypertension was defined as home systolic/diastolic BP≥135/85 mmHg and/or the use of antihypertensive medication. The prevalence of home hypertension was 39.4% for men and 29.3% for women. After adjustment for all potential confounding factors, the highest-tertile consumptions of fruits, vegetables, potassium, and vitamin C were associated with a significantly lower risk of hypertension (45%, 38%, 46%, and 43% lower risk of home hypertension, respectively). In conclusion, this cross-sectional study based on home BP measurement suggests that high-level consumptions of fruits, vegetables, potassium, and vitamin C are associated with a significantly lower risk of hypertension. (*Hypertens Res* 2008; 31: 1435–1443)

***Key Words*: fruit consumption, vegetable consumption, home blood pressure, hypertension, Japanese resident**

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Introduction

Hypertension is a major cause of morbidity and mortality (*1*). Many studies have indicated that high blood pressure (BP) is significantly associated with mortality (*2*) and increased risk of cardiovascular disease (CVD) events (*3*, *4*).

Numerous studies have reported that certain lifestyle choices, such as maintaining a normal body weight, engaging in routine physical activity, and reducing sodium and alcohol intake, can lead to undeniable reductions in BP levels and the prevalence of hypertension (*5*). Among these preventive factors, it is well acknowledged that dietary factors play an important role in the modulation of BP in hypertensive or normotensive individuals (*5–15*). Fruit and vegetable consumption has an especially powerful association with lower levels of BP and a lower risk of hypertension (*7*, *14*, *15*). Intake of potassium, calcium, magnesium, fiber, and protein derived from plants have also been shown to be associated with lower levels of BP (*7*, *8*, *15–17*).

However, most studies have focused mainly on community residents or high risk subjects in Western countries, and there have been few reports on the relationship of diet to BP in Asian populations. Since there are geographical differences in types of food consumption and risk factors among countries (*18*, *19*), it is important to confirm the reproducibility of previous results regarding the association between BP and food and nutrient components for individual populations.

Furthermore, most of these previous studies used conventional BP (CBP) measurements taken in medical settings. CBP measurement can lead to the white-coat effect which is a condition characterized by an elevated BP in a medical setting (*20*). Thus previous studies may have overestimated the risk of high BP. Self-measurement of BP at home is not influenced by observer or regression dilution biases or the white-coat effect (*20–24*). Furthermore, home BP measurements make it possible to obtain multiple measurements over a long observation period under relatively controlled conditions (*21*, *24*). Because of these benefits, home BP measurements are now widely used and recommended in several national and international guidelines (*25*, *26*). Home BP measurements are now considered more accurate and reliable to reflect target organ damage and the prognosis of cardiovascular disease than CBP measurement taken in a medical setting (*21–27*).

The aim of this study was to investigate the association of fruit and vegetable consumption with the risk of hypertension diagnosed by home BP.

Methods

Ohasama Study

The present study is a part of the Ohasama study, a longitudinal community-based observational study of individuals who have participated in the study of home BP measurement project in Ohasama, Iwate Prefecture, Japan. The geographic and demographic characteristics of study subjects have been reported previously (*23*, *28*).

This study was approved by the Institutional Review Board of Tohoku University School of Medicine and by the Department of Health of the Ohasama Town Government and informed consent was obtained from all subjects.

Subjects

The total population of Ohasama was 7,202 in 1998. Among this total, 4,964 were 35 years or over. Two-hundred thirteen subjects were excluded from the study because they were hospitalized, mentally ill, or bedridden, and 1,410 subjects who worked outside of the town were also excluded. Of the remaining 3,341 eligible subjects, 1,931 subjects (808 men and 1,123 women) gave their informed consent to participate in the study of home BP measurements. A total of 362 subjects (166 men and 196 women) were excluded for the following reasons: <3 measurements of home BP (n=114; 58 men and 56 women), incomplete questionnaire (n=167; 81 men and 86 women), or extreme levels of energy intake (above or below 2.5% of the range for all participants: n=81; 27 men and 54 women). Finally, data from 1,569 individuals (642 men and 927 women) were analyzed.

Variables

Home BP Measurement

Home BP was measured using the HEM701C (Omron Healthcare Co. Ltd., Kyoto, Japan), a semi-automatic device based on the cuff-oscillometric method (*29*), which generates a digital display of both systolic BP (SBP) and diastolic BP (DBP). These devices have been previously validated (*29*) and satisfy the criteria of the Association for the Advancement of Medical Instrumentation. Since the arm circumference was usually <34 cm, we used a standard arm cuff (*30*).

Prior to measurement, physicians and public health nurses conducted health education classes to teach the participants how to measure their own BP. They also assessed whether the participants were able to measure their own BP correctly. Of the households in the town, 80% attended the classes, and public health nurses visited all of the remaining households to provide similar information (*28*, *31*). The participants were then asked to measure and record their BP once every morning for 4 weeks within 1 h of awakening, before breakfast and before taking any drugs, while seated and after an at least 2-min rest. The participants measured their BP at least twice on each occasion, although only the first value on each occasion was recorded on the worksheet to exclude selection bias by the participants (*24*). In the present study, home BP was defined as the mean of all first measurements recorded during the 4-week period. The mean (±SD) number of home BP measurements was 22±6. Hypertension was defined as use of antihypertensive medication and/or a home BP value of 135/

85 mmHg or over.

Food Frequency Questionnaire

Standardized methodology was used to calculate fruit and vegetable consumption and their related nutrients from data obtained in a Japanese version of the food-frequency questionnaire (FFQ). The reproducibility and validity of this questionnaire have been reported in detail (*32*). In brief, the studies were conducted to examine the validity of 17 specific nutrients of interest (*32*). The participants in the present study were similar and lived in northeast Japan. Pearson's correlation coefficient was used to compare nutrients recorded in the four 3-d diet records over a 1-year period with those in two FFQs obtained with a 1-year interval between them to take into account seasonal variations in food consumption. Seventeen nutrients were analyzed and the correlations ranged from 0.24 to 0.85 (median 0.43) for the first FFQ, and from 0.47 to 0.91 (median 0.68) for the second. The observed r^2 value between every nutrient and the 141 selected food items from the FFQ data was >0.9. We examined the consumption of 14 fruits and 19 vegetables. The questionnaire asked about the average frequency of consumption of each food during the previous year. The nine frequency categories ranged from no consumption to seven or more times per day. A standard portion size of one serving was specified for each food, and respondents were asked if their usual portion was larger (>1.5 times), the same, or smaller (<0.5) than the standard. In the present study, we took into account energy from alcohol from foods, *e.g.*, certain seasonings that include alcohol. But we did not consider alcohol derived directly from beer, wine, or other alcoholic beverages, in the total energy count. Nutritional supplements were not taken into account because there were few supplement users. In order to determine the efficacy of the nutrients of the food groups studied, the dietary contents of nutrients, *i.e.*, potassium, vitamin C and β-carotene, were estimated by analyzing the FFQ results. All food consumption and nutrients were adjusted for total energy intake using the residual method (*33–35*). Following this procedure, subjects were divided into tertiles to indicate low, medium, and high levels of each food and nutrient consumption.

Other Putative Confounding Factors Related to BP

With regard to smoking habits, subjects were defined as nonsmokers, which included never- and ex-smokers, or current smokers. Alcohol consumption was defined as rarely or never; <540 mL of sake/d; or ≥540 mL of sake/d (540 mL of sake=81 g of alcohol). With regard to frequency of exercise, subjects were also categorized according to their answer to the question, "How many times do you normally exercise per week?" The responses were divided into three groups according to the frequency of exercise: rarely or never (<1 h/week); 1 or 2 h/week; and ≥3 h/week. Anthropometric measures (height, body weight) were recorded by a standardized protocol. The body mass index (BMI) was calculated as weight (kg)/height^2 (m^2) and was classified as under- or normal weight (≤24.9 kg/m^2), and overweight (≥25.0 kg/m^2). Trained public health nurses measured anthropomorphic parameters at the time of the annual health check. Past history of diabetes and hypercholesterolemia was also taken into account in the study.

Table 1. Characteristics of All Subjects (*n*=1,931)

Factors	Non participants	Participants	*p*-value
No. of subjects	362	1,569	
Gender (men, %)	45.6	41.0	0.062
Age	63.4±14.4	60.0±12.8	<0.0001
Alcohol consumption (%)			0.357
Rarely or never	57.2	61.3	
<540 mL/d	38.2	34.8	
≥540 mL/d	4.5	3.9	
Smoking status (%)			0.002
Never	69.6	71.7	
Ex-smoker	12.7	7.3	
Current	17.7	21.0	
Frequency of exercise (%)			0.918
Rarely or never	6.4	6.0	
1 or 2 h/week	13.3	14.0	
≥3 h/week	80.4	80.1	
Energy and nutrients			
Total energy (kcal/d)	2,607±1,929	2,442±940	0.018
Fat (g/d)*	67.4±17.6	62.3±13.8	<0.0001
Sodium (mg/d)*	6,929±3,132	6,319±1,899	<0.0001
BMI (≥25 kg/m^2, %)	7.7	14.4	<0.0001
Home BP (mmHg)			
Systolic	128±12	122±15	<0.0001
Diastolic	77±10	75±9	0.004

*Data were adjusted for total energy by the residual method. Continuous variables are presented as mean±SD. BMI, body mass index.

Statistical Analysis

The data of all subjects are expressed as the mean±SD or percentages. Differences between social and lifestyle characteristics of each fruit and vegetable intake were tested for statistical significance with Student's *t*-test, analysis of variance (ANOVA) for continuous variables or χ^2 test for categorical variables. To examine how the consumption of fruits and vegetables or other related nutrients was associated with a risk of hypertension (defined on the basis of home BP measurement), we conducted multiple logistic regression analyses after adjustment for the following putative confounding factors: sex, age, BMI, frequency of exercise, smoking status, alcohol consumption, energy-adjusted fat intake and sodium consumption, and past history of diabetes and hypercholester-

Table 2. Distribution of Characteristics across Tertile of Fruit and Vegetable Consumption (*n*=1,569)

Factors	Fruit				Vegetable			
	Lowest (*n*=523)	Medium (*n*=523)	Highest (*n*=523)	*p*-value	Lowest (*n*=523)	Medium (*n*=523)	Highest (*n*=523)	*p*-value
Mean consumption (g/d)	15.6	84.2	222.7		18.5	56.8	112.7	
Gender (men, %)	62.3	38.6	21.8	<0.0001	67.3	34.8	20.7	<0.0001
Age	57.8±13.1	61.2±13.0	61.0±11.9	<0.0001	57.2±13.1	61.3±13.1	61.5±11.6	<0.0001
Alcohol consumption (%)				<0.0001				<0.0001
Rarely or never	40.3	61.8	70.0		41.5	62.5	68.1	
<540 mL/d	51.2	35.0	28.1		50.1	34.6	29.6	
≥540 mL/d	8.4	3.3	1.9		8.4	2.9	2.3	
Smoking status (%)				<0.0001				<0.0001
Never	57.6	73.4	84.5		54.3	75.1	86.0	
Ex-smoker	9.4	7.8	4.2		10.9	6.3	4.2	
Current	33.1	18.7	11.3		34.8	18.5	9.8	
Frequency of exercise (%)				0.187				0.758
Rarely or never	6.1	5.9	5.7		5.4	6.3	6.1	
1 or 2 h/week	17.0	12.8	12.2		15.3	12.0	14.7	
≥3 h/week	76.9	81.3	82.0		79.3	81.6	79.2	
Energy and nutrients								
Total energy (kcal/d)	2,609±812	1,894±783	2,371±831	<0.0001	2,584±804	1,926±797	2,364±849	<0.0001
Fat (g/d)*	58.9±16.2	61.6±11.1	61.5±11.6	0.001	55.7±15.0	62.3±10.4	64.0±12.4	<0.0001
Sodium (mg/d)*	5,813±2,205	6,296±1,651	6,765±1,814	<0.0001	5,090±1,740	6,196±1,252	7,888±1,897	<0.0001
BMI (≥25 kg/m^2, %)	11.3	16.1	15.9	0.045	10.3	14.3	18.5	0.001
Prevalence of hypertension (%)	35.2	35.6	29.6	0.075	33.3	31.4	35.8	0.319
Using antihypertensive medication (%)	17.6	19.1	19.1	0.764	14.1	18.9	22.8	0.002
Home BP in untreated participants (mmHg)								
Systolic	121±12	120±16	117±14	<0.0001	121±13	119±14	118±14	0.001
Diastolic	76±9	74±10	73±9	<0.0001	76±9	73±9	73±9	<0.0001

*Data were adjusted for total energy by the residual method. Continuous variables are presented as mean±SD. Analysis of variance (ANOVA) for continuous variables or χ^2 test for categorical variables were used for the comparison across tertiles of consumption of fruit and vegetables. BMI, body mass index; BP, blood pressure.

olemia. We tested the interaction among these factors by introducing a multiplicative term into the models.

For all analyses, statistical significance was defined as a two-tailed p value <0.05. All analyses were conducted using SPSS software version 12 for Windows (SPSS Inc., Chicago, USA).

Results

The mean consumptions of fruits and vegetables were 108 and 63 g/d, respectively. The mean home SBP/DBP levels were 122/75 mmHg. The mean BMI was 23.2±3.1 kg/m^2 for men and 23.4±3.1 kg/m^2 for women. Percentages of past history of diabetes and hypercholesterolemia were 9.8% and 2.6% for men and 9.0% and 5.5% for women, respectively. Percentages of subjects receiving antihypertension medication were 18.4% for men and 18.8% for women. The prevalences of home hypertension, which was defined as the use of antihypertensive medication and/or a home BP value of 135/85 mmHg or over, were 39.4% for men and 29.3% for women.

Table 1 compares the characteristics of the included study subjects with those who participated in the study but who were ultimately excluded based on the exclusion criteria. Those who completely fulfilled the study criteria were characterized by a higher proportion of current smokers, a lower amount of total energy intake, and a higher BMI.

Table 2 shows the relationships of social and lifestyle characteristics of potential risk factors for hypertension in each category of fruit and vegetable consumption. Compared with those in the lowest tertile of fruit consumption, those in the highest-tertile were more likely to be women, never or ex-smokers, and older. They were also likely to have higher BMI and lower amounts of alcohol consumption. We observed similar tendencies for vegetable consumption. The frequency of exercise did not differ among the fruit and vegetable con-

Table 3. Odds Ratio (95% Confidence Interval) for the Association between Fruit and Vegetable Consumption and the Risk of Home Hypertension (n=1,569)

	No.	Adjusted*	p-value	Adjusted#	p-value
Fruit					
Highest	523	0.65 (0.47–0.91)	0.011	0.55 (0.37–0.81)	0.002
Medium	523	0.86 (0.63–1.17)	0.324	0.82 (0.57–1.18)	0.291
Lowest	523	Ref.		Ref.	
p for trend		0.038		0.009	
Vegetable					
Highest	523	0.84 (0.60–1.17)	0.306	0.62 (0.40–0.95)	0.029
Medium	523	0.69 (0.50–0.95)	0.023	0.57 (0.39–0.84)	0.005
Lowest	523	Ref.		Ref.	
p for trend		0.076		0.012	
Potassium					
Highest	523	0.70 (0.50–0.99)	0.045	0.54 (0.32–0.88)	0.015
Medium	522	0.69 (0.49–0.96)	0.028	0.48 (0.31–0.73)	0.001
Lowest	524	Ref.		Ref.	
p for trend		0.057		0.003	
Vitamin C					
Highest	522	0.75 (0.54–1.05)	0.089	0.57 (0.37–0.87)	0.010
Medium	524	0.83 (0.60–1.15)	0.258	0.70 (0.48–1.02)	0.064
Lowest	523	Ref.		Ref.	
p for trend		0.226		0.030	
β-Carotene					
Highest	522	0.75 (0.53–1.07)	0.113	0.67 (0.42–1.06)	0.087
Medium	523	0.81 (0.58–1.12)	0.200	0.69 (0.46–1.03)	0.067
Lowest	524	Ref.		Ref.	
p for trend		0.253		0.136	

*Adjusted for age, gender, and BMI. #Adjusted for age, gender, BMI, frequency of exercise, smoking status, alcohol consumption, fat intake, sodium consumption, and past history of diabetes and hypercholesterolemia. BMI, body mass index.

sumption tertiles. Although the highest vegetable consumption tertile was significantly related to higher prevalence of using antihypertensive medication and the lower fruit and vegetable consumption tertiles were associated with higher home BP in untreated participants, the prevalence of hypertension was not related to the consumption levels.

Table 3 shows the association between fruit and vegetable consumption and the reduction of home hypertension risk in the total subjects. Since we had confirmed that the association was similarly observed in men and women (data not shown), we combined both sexes in the analysis. In the sex- and BMI-adjusted analysis, the highest-tertile of fruit consumption showed a significant relationship with a lower risk for home hypertension (the highest-tertile for fruit consumption: odds ratio 0.65, p=0.011). After adjustment for known risk factors for hypertension such as age, gender, BMI, frequency of exercise, smoking status, alcohol consumption, fat intake, sodium consumption, and past history of diabetes and hypercholesterolemia, these associations did not change. Compared to the lowest fruit consumption tertile, a 45% lower risk of home hypertension was found in those in the highest fruit consumption tertile (p=0.002). The highest vegetable consumption tertile the highest consumption tertile for other related nutrients also showed significant positive associations with lower risks of home hypertension (the highest-tertile for vegetable consumption: 0.62, p=0.029; the highest-tertile for potassium: 0.54, p=0.015; and the highest-tertile for vitamin C: 0.57, p=0.010). In this study, no significant interaction was found between the consumption of fruits, vegetables or the other related nutrients and putative confounding factors. The results did not change when adjusted for absolute sodium intake instead of "total energy-adjusted" (residual method) sodium intake (data not shown).

Discussion

The foregoing analysis demonstrated that high level consumptions of fruits, vegetables, and other related micronutrients, *i.e.*, potassium and vitamin C, are potentially associated with a lower risk of uncontrolled hypertension. The association did not alter after adjustment for putative confounding factors.

Fruit/Vegetable Consumption and Home Hypertension

We found that high-level consumptions of fruits and vegetables were associated with a significantly lower risk of hypertension as measured by home BP. The results from several previous studies examining the association between fruit and vegetable consumption and CBP using a combination of fruits and vegetables are partially consistent with the present findings (*7*, *14*, *15*). The Seguimiento Universidad de Navarra study demonstrated that high-level consumption of vegetables was inversely associated with BP levels, whereas they did not find any associations with fruit consumption (*36*). Geographical differences in types of food consumption might be related to BP levels. In the present study, we also found a significant association between the medium-level consumption of vegetables and a lower risk of hypertension. The present study showed that those who consumed more fruits and vegetables also had higher fat and sodium intake. This might have been attributable to cooking methods, such as the use of soy sauce, table salt, and other seasonings, or the method of cooking vegetables, such as deep frying. The higher fat intake among those who consumed more fruit might have been attributable to the close correlation between the consumption of fruits and vegetables and the consumption of fats.

Other Related Micronutrients and Home Hypertension

In the present study, we found strongly significant associations between high potassium and vitamin C intake and a lower risk of home hypertension. Several mechanisms have been proposed to explain the inverse association between these nutrients and BP or risk of hypertension, including the idea that the antioxidant properties of these nutrients reduce BP. The observation of an inverse relationship between potassium intake and BP was consistent with previous studies (*37*, *38*). We also found a tendency for β-carotene to reduce the risk of hypertension, although this effect was not statistically significant. However, such an effect of β-carotene is still considered controversial. Several epidemiological studies have suggested an inverse association between dietary intake of fruits and vegetables containing β-carotene and BP levels and a risk of developing hypertension (*39*, *40*), but in randomized control trials using β-carotene supplements, these associations were inconsistent (*41–43*). Since intervention trials using vitamin supplements in an attempt to reduce mortality from cardiovascular disease have produced little evidence (*7*, *44*), or sometimes suggested harmful effects (*45*), current evidence points to the beneficial effects of eating more fruits and vegetables containing β-carotene rather than supplementation. Further prospective studies would be useful to specifically clarify how dietary micronutrients are related to the progression of hypertension and to risk factors for hypertension.

It is generally known that intake of vitamin C has a strong correlation with high-level fruit and vegetable consumption. Thus, a high vitamin C intake seems to contribute to lower BP levels. The effect of vitamin C on BP is also still disputable. A previous study indicated that the total vitamin C intake (food plus supplements) seems to be less associated with lower BP than the intake of fruits and vegetables themselves (*46*). Another study also reported that there were no beneficial effects from low-dose antioxidant supplementation that included vitamin C and vitamin E in a 6.5-year randomized analysis of BP (*41*). It seems that increased intake of a certain nutrient alone might not fully contribute to lowering BP. A combination of vitamins and minerals may be needed in order to prevent BP elevation.

On the other hand, there is evidence that some antihypertensive medications, such as angiotensin converting enzyme inhibitors or angiotensin II receptor blockers, increase the risk of hyperkalemia (*47–49*), so dietary education or advice by doctors, pharmacists, or dieticians may often include the admonition to avoid foods containing high levels of potassium, such as bananas and prunes. For this reason, subjects who were using antihypertensive medication may have tended to avoid eating foods containing high levels of potassium.

Study Strengths and Limitations

Home BP can eliminate several biases, including the white-coat effect (*20–23*, *28*), and thus a strength of the present study was that the results may have more accurately assessed the relationship between BP and fruit/vegetable consumption than similar studies using office BP. Thus, we could say that those who did not use antihypertensive medication but had uncontrolled home hypertension were a high risk group, and accurate early diagnosis or highly consciousness of high BP and subsequent medication or dietary intervention are expected to clarify in general subjects.

Several limitations of the present study need to be discussed. First, we could not determine whether additional sodium was consumed in the form of table salt or salt added during cooking. Also, we did not monitor the consumption of pre-packaged, convenience, or fast-foods, or the frequency of high-sodium restaurant foods. Even though we found that sodium intake in our FFQ was correlated with sodium intake in the four 3-d diet records over a 1-year period, neither method is very reliable for assessing dietary salt intake in particular, because they do not estimate the discretionary salt intake. Therefore, the true sodium intake might be underestimated.

Second, the information on food and nutrient consumption in the present study were obtained on the basis of a dietary recall. The correlation between the FFQ and the actual diet has been well established, but several problems remain. For example, the FFQ has a limited number of items and minimal information about portion size and it is not intended to provide accurate estimates of absolute intake. On the other hand, dietary assessment of sodium is considered to be difficult because of the wider "intra-subject" variation (*50*), and the difficulty in the assessment of seasoning. Although the measurement of urinary sodium excretion using urine samples collected over multiple days might be considered a reliable method, it would be very hard in general to estimate sodium intake by dietary survey (*51*, *52*). Lastly, since the present study was cross-sectional, further follow-up is required to clarify the relationship between fruit and vegetable consumption and the risk of developing hypertension.

Furthermore, the possibility of selection bias needs to be considered when generalizing the present findings, because only 47.0% of those eligible to participate in the study agreed to take part and the nonparticipants were older, and had higher BP levels and higher energy intake in comparison to those who participated in the study: it is possible that the participants had to be sufficiently independent to participate in this survey based on self-reported FFQ. Moreover, marked differences also exist in the epidemiology of home hypertension between Japan and the Western countries (*53*). Thus further research in other ethnic and cultural populations is needed to confirm the generalizability of our findings.

In the present study, we found an association between low-level consumption of fruits and increased risk of uncontrolled hypertension among subjects who did not use antihypertensive medication. However, since all subjects who were receiving antihypertensive medication had been diagnosed with hypertension, their dietary habits may already have been changed.

The risk of hypertension could be attributable to other food groups. For example, Kihara *et al*. reported that inorganic sulfate/urea nitrogen, an index related to the dietary score of sulfur-containing amino acids derived mainly from animal protein, were both negatively associated with SBP (*37*). However, even though other studies have reported that consumption of high levels of fruits and vegetables could be independently associated with a lower risk of hypertension, such evidence is less frequently reported in Asian populations. Furthermore, since people consume diets consisting of a variety of foods with complex nutrient combinations, focusing on only single nutrients or foods could result in the identification of erroneous associations between dietary factors and disease. A dietary pattern approach using factor and cluster analyses could provide more useful information about the risks of home hypertension in future studies.

Conclusions

The present results from the Ohasama study suggest that high-level consumptions of fruits, vegetables, and other related micronutrients present mainly in fruits and vegetables are potentially associated with a lower risk of hypertension. While the mechanism for BP-lowering *via* fruit and vegetable consumption is not yet clear (*54*, *55*), selective consumption of healthy foods and nutrients may lead to prevention and treatment of hypertension.

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