High fruit intake is associated with a lower risk of future hypertension determined by home blood pressure measurement: the OHASAMA study

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We investigate associations of fruit and vegetable intake with the risk of future hypertension using home blood pressure in a general population from Ohasama, Japan. We obtained data from 745 residents aged ≥35 years without home hypertension at baseline. Dietary intake was measured using a validated 141-item food frequency questionnaire, and subjects were then divided into quartiles according to the fruit and vegetable intake. Home hypertension was defined as home systolic/diastolic blood pressure of ≥135/85 mm Hg and/or the use of antihypertensive medication. During a 4-year follow-up period, we identified 222 incident cases of home hypertension. After adjustment for all putative confounding factors, the highest quartile of fruit intake was associated with a significantly lower risk of future home hypertension (odds ratio 0.40, 95% confidence interval 0.22–0.74, P = 0.004). In conclusion, this study, based on home blood pressure measurement, suggests that higher intake of fruit is associated with a lower risk of future home hypertension.

Keywords: fruit intake; vegetable intake; nutrition; home blood pressure; home hypertension; healthy community resident

Introduction

Hypertension is a major cause of morbidity and mortality, with many studies indicating it to be significantly associated with an increased risk of cardiovascular disease (CVD) events. For several decades, researchers have mainly focused on the potentially adverse or preventive effects of various dietary factors. Among these, fruit and vegetable intake has a especially powerful association with lower blood pressure (BP), and was found to reduce the risk of hypertension. Our previous study using self-measured BP at home (home BP) found a significant cross-sectional association between intake of fruit and risk of hypertension. However, although most studies exclude subjects who report a dietary change resulting from a diagnosis, the cross-sectional studies cannot remove subjects who change their diet after the diagnosis of hypertension.

Furthermore, in the majority of these studies, the definition of hypertension was based on conventional BP measurements. Because of the white-coat effect, a condition characterized by an elevated BP reading in a medical setting, these studies often overestimate the risk of high BP. On the other hand, home BP measurements enable researchers to obtain multiple measurements over a long observation period under relatively controlled conditions. The main strength of home BP is that it is not influenced by observer and regression dilution biases or the white-coat effect. Because of these benefits, home BP measurements are now...
considered a more accurate and reliable way of reflecting target organ damage and the prognosis of CVD when compared with conventional BP measurement taken in a medical setting,\textsuperscript{19–22} and are also recommended in several general hypertension guidelines.\textsuperscript{23,24}

Moreover, as there are geographical differences in the types of food intake and risk factors among countries,\textsuperscript{25,26} it is important to confirm the reproducibility of previous findings of associations between BP and food and nutrient components in each population.

The aim of this study was to examine the association of fruit and vegetable intake with the risk of hypertension diagnosed by home BP during 4 years of follow-up in a Japanese general population.

**Subjects and methods**

**Design**

This study was part of the Ohasama study, a longitudinal community-based observational study of individuals who have participated in a home BP measurement project in Ohasama, Iwate prefecture, Japan. The geographic and demographic characteristics of the study subjects have been reported previously.\textsuperscript{19,27}

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. Subjects provided written informed consent to participate.

**Study population**

In 1998, there were 5081 individuals aged \( \geq 35 \) years in Ohasama. Of the 4628 who answered the questionnaire (response rate 91.1\%), 1820 subjects took part in home BP measurement; these individuals collected their own BP data on at least 3 days during the 4-week measurement period in 1998. Among those, people who had home hypertension at baseline \((n = 394)\) and those who died \((n = 43)\) or moved away from the town \((n = 5)\) before the follow-up measurements were excluded from the study. Of the remaining 1378 eligible individuals, 805 subjects (58\%) took part in the follow-up home BP measurements.

In addition, 60 subjects were excluded for the following reasons: those who took <3 home BP measurements at follow-up \((n = 20)\) and those who had extreme levels of energy intake (in the upper or lower 2.5\% of the range for all subjects: \( n = 40)\). Finally, data from 745 subjects who were normotensive on baseline home BP (274 men and 471 women) were analysed. Compared with those who were ultimately excluded based on the exclusion criteria of the 1378 eligible individuals, the 745 participants who completely fulfilled the study criteria were more likely to be men, and of older age.

**Home BP measurement**

Baseline home BP was measured using the HEM701C monitor (Omron Healthcare Co., Ltd, Kyoto, Japan), a semiautomatic device based on the cuff-oscillometric method, which generates a digital display of both systolic BP and diastolic BP. We used HEM747ICN devices (Omron) for follow-up measurements. Both devices have been validated\textsuperscript{28} and satisfy the criteria of the Association for the Advancement of Medical Instrumentation (the HEM747ICN is exactly same as the Omron HEM735C except that the latter does not incorporate an integrated circuit memory). As the circumference of the arm was <34 cm in most cases, we used a standard arm cuff in all cases.\textsuperscript{27} In this study, home BP was defined as the mean of all first measurements recorded during the 4-week period. The mean (\pm s.d.) number of home BP measurements was 23 \( \pm 6\). Hypertension was defined as use of anti-hypertensive medication and/or home BP values of \( \geq 135/85 \) mm Hg at follow-up measurement.\textsuperscript{20–24}

**Food frequency questionnaire**

Standardized methodology was used to calculate fruit and vegetable intake from data obtained in a Japanese version of a food frequency questionnaire. The reproducibility and validity of this questionnaire were previously reported in detail.\textsuperscript{29,30} The questionnaire asked about the average frequency of intake of each food during the previous year according to nine frequency categories ranging from no consumption to \( \geq 7 \) times per day. A standard portion size of one serving was specified for each food, and respondents were asked whether their usual portion was larger (\( > 1.5 \) times), the same or smaller (\( < 0.5 \)) than the standard. In this study, we took into account energy from food sources of alcohol; for example, seasonings that include alcohol. However, we did not consider alcohol derived from alcoholic drinks such as beer and wine in the total energy count because we treated such alcohol intake as a separate variable. Nutritional supplements were not taken into account because there were few supplement users.

All food and nutrient intakes were adjusted for total energy intake using the residual method,\textsuperscript{31–33} and separate regression models were performed to obtain the residuals for men and women. Following this procedure, subjects were divided into quartiles according to the intake of fruit and vegetables. In this study, the lowest quartiles were used as reference categories.

**Statistical analysis**

To examine how the intake of fruit or vegetables was associated with the risk of future home hypertension defined on the basis of home BP measurement, we used multiple logistic regression analyses after adjustment for other putative confounding factors
related to hypertension. These were gender (men/women), age (continuous), body mass index (BMI; \(<25/25\) kg m\(^{-2}\)), frequency of exercise (rarely or never, 1 or 2 h per week and >3 h per week), smoking status (never, past or current smoker), alcohol consumption (rarely or never, \(<540\) ml of sake per day and \(\geq540\) ml of sake per day: 540 ml of sake = 81 g of alcohol), energy-adjusted fat intake and sodium intake (continuous), baseline systolic home BP (continuous) and a history of diabetes, hypercholesterolaemia and CVD (yes/no).

Moreover, we stratified the analysis by lifestyle factors, such as overweight (BMI = 25 kg/m\(^{-2}\) as cutoff), frequency of exercise, smoking status and alcohol consumption, to explore associations related to these factors. We tested interactions by introducing a multiplicative term into the main effect models. We also examined the combined effects of risk factors and fruit or vegetable intakes. For all analyses, statistical significance was defined as a two-tailed \(P\)-value of <0.05. All analyses were conducted using SPSS software version 14 for Windows (SPSS Inc., Chicago, IL, USA).

**Results**

At the time of the follow-up measurements, 222 subjects (29.8%) had developed home hypertension (mean duration of follow-up: 4.1 years). Among these, 70 were defined as having home hypertension because they had started treatment with antihypertensive medication.

The distributions of characteristics across quartile of each fruit and vegetable intake at baseline are shown in Table 1. In the study, the most commonly consumed type of fruit was citrus fruit (18.5 g day\(^{-1}\)), followed by apple (8.6 g day\(^{-1}\)), grape (5.9 g day\(^{-1}\)) and watermelon (5.6 g day\(^{-1}\)). Compared with those in the highest quartile of fruit intake, those in the lowest quartile were more likely to be men, of younger age, current smokers, heavier drinkers and with lower diastolic home BP. Subjects with the highest quartile of fruit intake tended to consume less energy and carbohydrate and more sodium, and fruit- and vegetable-related nutrients (that is, potassium, magnesium, \(\beta\)-carotene, folate, vitamin C and total dietary fibre) than subjects in the lowest quartile. As for food intake, the highest intake of fruit was associated with low intakes of rice, bread and noodles, and with high intakes of vegetables and seaweeds. Compared with those with the highest quartile of fruit intake, subjects with quartile 3 of fruit intake reported more fat and less protein and calcium intake (table not shown, intake in quartile 3; fat, 42.7 ± 0.8 g; protein, 61.6 ± 0.6 g; and calcium 630 ± 14 mg). We observed similar tendencies for vegetable intake. In each category, the frequency of exercise and incidence of home hypertension at follow-up did not differ.

Table 2 shows the association between fruit and vegetable intake and the risk of future home hypertension. In the sex- and BMI-adjusted analysis, the highest quartile of fruit intake was associated with a significantly lower risk for future home hypertension (odds ratio compared with the lowest quartile for fruit intake: 0.44; \(P = 0.005\)), whereas no association was observed for vegetable intake. After adjustment for putative confounding factors, these associations did not change. Compared with the lowest quartile for intake of fruit, a 60.0% lower risk of hypertension was found in those with the highest quartile of fruit intake (\(P = 0.004\)). Further adjustment for putative confounding factors, vegetables and related nutrients (potassium, \(\beta\)-carotene, folate, vitamin C and total fibre) attenuated these results, but there was still a significantly lower risk of future home hypertension in the highest quartile of fruit intake (odds ratio = 0.45; \(P = 0.025\)).

Regarding joint classification of quartiles of fruit intake and risk factors for home hypertension, Figure 1 shows the risk associated with BMI status at each quartile of fruit intake. The odds ratio for the comparison of overweight with highest quartile of fruit intake to overweight with lowest quartile of fruit intake was 0.21 (\(P = 0.005\)). There was no significant interaction between BMI and fruit intake (\(P > 0.10\)). When we adjusted for baseline diastolic home BP instead of systolic home BP, the results were almost the same.

**Discussion**

This study indicated that high fruit intake is strongly associated with a lower risk of future home hypertension. The inverse association between fruit intake and future home hypertension was persistent among subgroups of overweight and normal-weight individuals.

Our study has several strengths. It is the first to examine whether fruit and vegetable intake predicts hypertension measured by home BP. Measuring BP at home can eliminate several biases, such as the white-coat effect,\(^{20–22}\) and therefore the results might more accurately determine the relationship between BP and fruit and vegetable intake. Because of the prospective design and exclusion of hypertensive subjects at baseline, we believe we could minimize the number of subjects who changed their diet because of a diagnosis of high BP.

The second strength is that, to the best of our knowledge, this is the first study to clarify the association between fruit and vegetable intake and future hypertension in Asian subjects.

*Fruit/vegetable intake and future home hypertension*

We found that high fruit intake was linked to a lower risk of future home hypertension, whereas no association was observed for high vegetable intake.
Table 1 Distribution of characteristics across quartiles of fruit and vegetable intake (n = 745)

<table>
<thead>
<tr>
<th></th>
<th>Quartile of fruit consumption</th>
<th>P-value</th>
<th>Quartile of vegetable consumption</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 (n = 187)</td>
<td></td>
<td>4 (n = 186)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 (n = 187)</td>
<td></td>
<td>3 (n = 186)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 (n = 186)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender (men %)</td>
<td>51.3 ± 2.3</td>
<td>0.63</td>
<td>62.6 ± 0.8</td>
<td>0.0001</td>
</tr>
<tr>
<td>Age</td>
<td>55.3 ± 0.8</td>
<td>0.005</td>
<td>54.2 ± 0.8</td>
<td>0.0001</td>
</tr>
<tr>
<td>Alcohol consumption (%)</td>
<td>0.010</td>
<td></td>
<td>59.0 ± 0.8</td>
<td>0.0001</td>
</tr>
<tr>
<td>Rarely or never</td>
<td>68.4 ± 3.7</td>
<td></td>
<td>68.4 ± 3.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>&lt;540 ml of sake per day</td>
<td>28.2 ± 3.7</td>
<td></td>
<td>27.3 ± 3.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>≥540 ml of sake per day</td>
<td>28.5 ± 3.7</td>
<td></td>
<td>27.3 ± 3.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>Current smokers (%)</td>
<td>27.8 ± 3.7</td>
<td></td>
<td>27.8 ± 3.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>Exercise (rarely or never)</td>
<td>76.5 ± 3.7</td>
<td></td>
<td>77.9 ± 3.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>Body mass index (kg m⁻²; ≥25%)</td>
<td>21.9 ± 3.7</td>
<td></td>
<td>20.9 ± 3.7</td>
<td>0.0001</td>
</tr>
<tr>
<td>Home BP (mm Hg)</td>
<td>115.8 ± 0.7</td>
<td>0.273</td>
<td>115.8 ± 0.7</td>
<td>0.403</td>
</tr>
<tr>
<td>Systolic</td>
<td>73.2 ± 0.5</td>
<td>0.014</td>
<td>73.6 ± 0.5</td>
<td>0.002</td>
</tr>
<tr>
<td>Diastolic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean intakes of food and nutrients*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice, bread and noodles (g)</td>
<td>566 ± 6.5</td>
<td>&lt;0.0001</td>
<td>685 ± 15</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sugar (g)</td>
<td>6.6 ± 0.6</td>
<td>&lt;0.0001</td>
<td>8.0 ± 0.6</td>
<td>0.021</td>
</tr>
<tr>
<td>Nuts (g)</td>
<td>101.7 ± 4.7</td>
<td>&lt;0.0001</td>
<td>80.7 ± 7.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Pulses (g)</td>
<td>2.7 ± 0.6</td>
<td>&lt;0.0001</td>
<td>2.3 ± 0.5</td>
<td>0.001</td>
</tr>
<tr>
<td>Vegetables (g)</td>
<td>198.5 ± 8.4</td>
<td>&lt;0.0001</td>
<td>90.3 ± 3.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Seaweeds (g)</td>
<td>18.2 ± 1.1</td>
<td>&lt;0.0001</td>
<td>13.4 ± 1.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fish and shellfish (g)</td>
<td>65.1 ± 3.1</td>
<td>&lt;0.0001</td>
<td>47.2 ± 4</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Meats (g)</td>
<td>20.5 ± 1.1</td>
<td>&lt;0.0001</td>
<td>13.9 ± 0.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Eggs (g)</td>
<td>29.5 ± 2.7</td>
<td>&lt;0.0001</td>
<td>22.7 ± 1.5</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Dairy products (g)</td>
<td>220 ± 13</td>
<td>&lt;0.0001</td>
<td>241 ± 17</td>
<td>0.166</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>2163 ± 42</td>
<td>&lt;0.0001</td>
<td>2135 ± 38</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>64.1 ± 0.8</td>
<td>&lt;0.0001</td>
<td>56.7 ± 1</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>30.8 ± 0.9</td>
<td>&lt;0.0001</td>
<td>34.0 ± 0.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Carbohydrates (g)</td>
<td>299.4 ± 0.7</td>
<td>&lt;0.0001</td>
<td>305.9 ± 8.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>4264 ± 151</td>
<td>&lt;0.0001</td>
<td>2959 ± 131</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>2396 ± 40</td>
<td>&lt;0.0001</td>
<td>1879 ± 23</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>631 ± 14</td>
<td>&lt;0.0001</td>
<td>549 ± 20</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>287 ± 1.5</td>
<td>&lt;0.0001</td>
<td>232 ± 5.2</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>β-carotene (µg)</td>
<td>2806 ± 138</td>
<td>&lt;0.0001</td>
<td>1477 ± 56</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>298.5 ± 8.5</td>
<td>&lt;0.0001</td>
<td>205.4 ± 6.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>59.9 ± 2.3</td>
<td>&lt;0.0001</td>
<td>44.2 ± 1.7</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Total dietary fibre (g)</td>
<td>14.8 ± 0.4</td>
<td>&lt;0.0001</td>
<td>10.3 ± 0.3</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Follow-up*  

|                          | Antihypertensive medication (%) | 9.1     | 7.0     | 0.250   | 4.3     | 11.3    | 0.037   |
|                          | Home BP (mm Hg)                 | 126.4 ± 1.1 | 123.9 ± 1.1 | 0.212   | 124.8 ± 1.1 | 124.4 ± 1.1 | 0.835   |
|                          | Systolic                       | 75.5 ± 0.7  | 73.4 ± 0.6  | 0.056   | 74.9 ± 0.7  | 72.8 ± 0.6  | 0.127   |
|                          | Diastolic                      | 34.8        | 24.2        | 0.076   | 31.6        | 26.9        | 0.450   |

Continuous variables are presented as mean ± s.e.  
One-way analysis of variance (ANOVA) was used for continuous variables and χ² test for categorical variables, comparing quartiles of each food group.  
*Statistical significance was defined as P<0.05 compared with quartile 1 (lowest) using Bonferroni post hoc test.  
*Data were adjusted for total energy by the residual method.  
*Mean duration of the period between the baseline and the follow-up home blood pressure (home BP) was 4.1 ± 0.7.  
*Home hypertension was defined as use of antihypertensive medication and/or home BP values of >135/85 mm Hg at follow-up.

Results of some studies, which examined the association between combined fruit and vegetable intake and risk of hypertension, are partially consistent with the present findings.¹⁴⁻⁶⁻³⁴ but no studies have shown significant inverse associations between intake of fruit alone and the risk of hypertension. Other studies have reported a significant protective association between intake of fruit and risk of CVD.¹⁵⁻¹⁶ Our results are consistent with this.

Other related nutrients and home hypertension  
We also analysed the intakes of potassium, folate, magnesium, vitamin C and β-carotene, which are highly correlated with fruit and vegetable intake. However, these dietary factors were not associated with the risk of home hypertension. Moreover, adjustment for these dietary factors did not significantly modify the findings. In this study, the most commonly consumed type of fruit was citrus fruit, followed by apple, grape and watermelon. Although
individual dietary factors, such as vitamin C and folate, were not associated with risk of home hypertension, it is possible that the total balance of these factors in these commonly consumed fruits might be useful for the prevention of future hypertension.

Characteristics of fruit intake

These result, however, showed a lack of continuity in terms of risk of hypertension for each quartile of fruit intake, despite the significant association between the highest quartile of fruit intake and a lower risk of hypertension. Subjects in the third quartile of fruit intake reported higher fat and lower protein intake than those in the highest quartile, and thus the risk of hypertension might be influenced by these factors.

We also found no association between the highest quartile intake of vegetables and risk of hypertension. This study confirmed the findings of our previous cross-sectional study,\(^1\) in that those who consumed more fruit and vegetables had higher sodium and fat intake. This might be attributable to seasonings, including soy sauce and table salt, and methods of cooking vegetables, such as deep frying. The higher fat and sodium intake among those who consumed more fruit might be attributable to the close correlation between the intake of fruit and vegetables. A number of factors, such as lifestyle, food availability, food culture and dietary habits, might also be related to BP and risk of hypertension.

In this study, we found significant differences in dietary characteristics across quartiles of fruit intake after adjusting for all putative confounding factors. Compared with subjects with higher intake of fruit,
those with the lowest intake of fruit consumed more carbohydrate-containing foods and meat, and less vegetables and seaweed. It therefore seems that a higher intake of fruit was associated with a healthier diet. As people consume diets consisting of a variety of foods with complex combinations of nutrients, the examination of only single foods could result in the identification of erroneous associations between dietary factors and disease. Furthermore, the risk of hypertension could be attributable to other food groups. When several nutrients with small BP-lowering effects are consumed together, the cumulative effects may be sufficient for detection. The dietary pattern approach using factor and cluster analyses\textsuperscript{35} could provide more information regarding risk of home hypertension in further studies.

**Study limitations**

Several limitations of this study need to be discussed. First, information regarding food and nutrient intake in this study was obtained on the basis of dietary recall. The correlation between the food frequency questionnaire and usual diet has been well established, but there are several problems, for example, limited number of items and minimal information about portion size.

Second, we did not find a significant interaction between fruit consumption and BMI. However, a gradient declining risk of home hypertension with increasing fruit intake was apparent only for the overweight subjects, suggesting that such an interaction may have been present. Therefore, it is possible that the lack of statistical significance was because of the small size of the eight subgroups. Larger studies would be needed to clarify the presence of a statistically significant interaction between fruit consumption and BMI.

The possibility of selection bias also needs to be considered when generalizing the present findings, because only 54.1\% of those eligible to participate in the study agreed to take part. As we excluded those who had home hypertension at baseline, this could mean that healthy people were more likely to be followed up. However, although the nonparticipants were older and had higher energy intake than those who participated in the study, other lifestyle factors did not differ significantly between participants and nonparticipants. Marked differences also exist in the epidemiology of home hypertension between Japan and Western countries;\textsuperscript{36} thus, further research in other ethnic and cultural populations is needed to confirm the generalizability of our findings.

In this study, a higher intake of fruit was associated with a healthier lifestyle such as limited alcohol intake and avoidance of smoking. Therefore, although we adjusted for these confounding factors, it is possible that other factors associated with healthier lifestyle not measured in this study might confound the findings. Further studies with more detailed information on lifestyle-associated factors are required to further investigate the association observed in this study.

**Conclusions**

The present results from the Ohasama study suggest that high intake of fruit is potentially associated with a lower risk of future home hypertension. Although the mechanism for BP lowering through fruit and vegetable intake remains unclear,\textsuperscript{37,38} selective intake of healthy foods and nutrients may prevent hypertension. Using home BP in general subjects enable to be considered highly health consciousness and subsequent early dietary intervention is expected to prevent hypertension and CVD.

**What is known about this topic**

- Fruit and vegetable intake has a powerful association with lower blood pressure and was found to reduce the risk of hypertension.
- But there are geographical differences in the types of food intake and risk factors among countries, and the relationship of diet with blood pressure in Asian populations has not been fully investigated.
- Furthermore, there is no study to examine the association between fruit and vegetable intake and the risk of future home hypertension determined by home blood pressure measurement.

**What this study adds**

- Higher intake of fruit is associated with a lower risk of future home hypertension.
- Higher intake of fruit is also associated with a healthier diet.

**Conflict of interest**

The authors declare no conflict of interest.

**Acknowledgements**

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References


