Original Article

Relationship between fruit and vegetable intake and the risk of metabolic syndrome and its disorders in Korean women according to menopausal status

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Background and Objectives: The association between fruit and vegetable (FV) intake and risk of the metabolic syndrome (MetS) has not been elucidated fully, particularly by menopausal status. **Method and Study Design**: The study population was 2,999 women aged 40-64 years participating in the 4th Korea National Health and Nutrition Examination Survey. The definition of MetS and its components was based on the modified National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III) for Koreans. Dietary data were assessed by a 24-hour recall. **Results**: Fruit intake was inversely related only to the risk of high blood pressure (BP), but not MetS. Total vegetable consumption was inversely associated with the MetS risk, and when combined with fruits, the inverse association was observed even in its features of high triglycerides (TG) and low HDL-cholesterol as well as MetS. Assessing women by menopausal status revealed that the inverse association with the MetS risk was found only in postmenopausal women having greater total vegetables and total FV intake (aOR=0.47, 95% CI=0.29-0.75, *p*-trend=0.003 and aOR=0.54, 95% CI=0.35-0.85, *p*-trend=0.007, respectively). Analysis regarding MetS features showed that while the inverse association of total vegetables or total FV intake was observed with high TG risk in postmenopausal women, fruits intake was inversely associated with high BP risk in premenopausal women (aOR=0.54, 95% CI=0.37-0.79, *p*-trend=0.004). **Conclusion**: Results suggest that while fruit intake was inversely associated with high BP in premenopausal women, greater dietary intake of vegetables and total FV may protect against the risk of MetS, particularly in postmenopausal women.

Key Words: fruits, vegetables, metabolic syndrome, menopause, women

INTRODUCTION

Metabolic syndrome (MetS) is characterized by impaired blood glucose, elevated blood pressure, dyslipidemia, and abdominal obesity. It was reported that its association with an increased risk of diabetes and cardiovascular disease (CVD) was apparent, particularly in women.[1] As the prevalence of MetS increases remarkably after 50 years of age,[2] it is considered that the pattern of MetS in women differs with menopausal status. Although the mechanism associated with the difference in MetS is not well understood, clinical and experimental evidence suggests that a dramatic decrease in endogenous estrogen after menopause[3,4] can lead to the emergence of MetS[5] and its disorders,[6] as well as CVD,[7] because estrogen does not provide sufficient protection against oxidative stress after menopause.[3,8-10] Oxidative stress, which has a central role in the atherosclerotic process, has been linked to the risk of MetS,[9,10] and its components[9] and oxidative stress levels, as measured by F2-isoprostane level, are lower in premenopausal women than in postmenopausal women.[11]

Fruits and vegetables (FV) are natural sources of phytochemicals, such as antioxidants and phytoestrogens. For example, antioxidants are important in inhibiting oxidative stress in the atherosclerotic process that leads to various degenerative diseases including CVD. Thus, the associations between FV consumption and the risk of CVD[3,4] and diabetes[5,6] have been studied extensively. In addition, phytoestrogens have a favorable effect on the risk of breast cancer[12] and cardiovascular risk factor metabolic score in women,[13] particularly in postmenopausal women. Therefore, these findings have led to the hypothesis that FV consumption, rich in phytochemicals may be inversely associated with the risk of MetS and its disorders in women, particularly in post-menopausal women. So far, only a few studies have investigated the direct relation of FV consumption with the MetS and its components,[7,9,10] and furthermore no study has been done with regard to menopausal status. Therefore, this study aimed to evaluate associations between fruit and/or vegetable intake and

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the risk of MetS and its disorders especially related to menopausal status among a nationally representative sample of Korean women.

SUBJECTS AND METHODS

Study population and data sets

The data analyzed in this study were based on cross-sectional study data acquired in the 4th Korea National Health and Nutrition Examination Survey (KNHANES), conducted by the Korean Ministry of Health and Welfare from 2007 to 2009. The 4th KNHANES was the first survey designed to conduct a continuous annual survey with year-round data collection. Additional details regarding study design and methods are provided elsewhere.[14] A total of 3,966 participants aged 40-64 years completed the dietary survey based on a 24-hour recall and health examination.

In order to accurately determine the relation of FV intakes with MetS, we excluded subjects who had a history of cardiovascular problems, cancer, or stroke (n=502) or who took a medication related to diabetes or hypertension (n=439). After further exclusion of subjects reporting extremely low or high energy intakes (<500 or >4500 kcal/d) (n=26), the analyzed study population consisted of 2,999 female subjects. Ethical approval for the KNHANES was obtained from the Institutional Review Board of the Korea Centers for Disease Control and Prevention (KCDC), and written consent was obtained from all participants. Further ethical approval is not required for the use of KNHANES data that is freely available, as subjects remain anonymous.

Definition of Metabolic Syndrome (MetS)

The definitions of MetS and its components were based on the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III). In accordance with the recommendations of the World Health Organization (WHO) and the Korean Society for the Study of Obesity, modified waist circumference values for Asians were used.[15] The criteria for elevated fasting blood glucose was based on the definition of the American Diabetes Association (≥100 mg/dL). Subjects with MetS were defined as those who had three or more of the following components: (1) central obesity: waist circumference ≥80 cm; (2) elevated blood pressure (BP): systolic BP ≥130 mmHg and/or diastolic BP ≥85 mmHg; (3) elevated glucose: fasting plasma glucose (FPG) ≥100 mg/dL; (4) elevated triglycerides (TG): TG ≥150 mg/dL; and (5) low HDL-cholesterol: HDL-cholesterol ≤50 mg/dL.

Dietary information

Dietary information was obtained from a 24-hour dietary recall. Twenty-four-hour recall of food intake on one weekday was administered by a trained dietary interviewer by the Korea Health Industry Development Institute. Supplementary tools such as food models, two-dimensional examples of portion sizes, and containers were used to aid in recall. From the 24-hour dietary recall, total daily FV intakes were estimated. Fruit intake included pure fruit juices and all raw, cooked, canned, frozen, or dried forms of fruits. Vegetable intakes included all raw, cooked, canned, frozen or dried forms of most edible vegetables, including seaweed, soybeans and mushrooms. To reflect Korean dietary preferences, vegetable intake did not include potatoes.

As suggested daily FV intakes and portion sizes vary among countries, we defined an adequate total intake of FV as a minimum of 500 gram per day, as suggested in the Korean Health Plan 2010 guidelines.[16] For fruit intake, the Korean Nutrition Society recommends two or three servings for adults aged 19–64 years.[17] We therefore defined an adequate intake as 200 gram per day.

Statistical analysis

To take into account the complex sampling design, primary sampling units, stratification, and sample weights were included in the analysis. To minimize the influence of age, age-adjusted percentages or means of the MetS and its components, health behaviors, and dietary factors, according to tertiles of total fruit and/or vegetable intake were estimated using regression analysis (PROC SURVEYREG). In addition, we analyzed vegetable intakes, excluding Kimchi, because Kimchi is a major source of vegetables in the Korean diet.[18] The trend test was performed by considering the median value of total intake of fruits and/or vegetables as a continuous variable. Health behaviors and dietary factors with low *p*-values in the trend test ($p<0.05$) were employed as potential confounders in further analyses. When highly correlated dietary factors are adjusted simultaneously, their relationships may be underestimated.[19] In this study, the age- and energy-adjusted partial correlation coefficient for carbohydrate and fat intake was -0.81. Moreover, carbohydrates may contribute more to the risk of MetS among Koreans than other ethnicities due to the Korean dietary pattern of high carbohydrate consumption and the modifying effect of carbohydrates on the association between FV intake and ischemic CVD.[20] Therefore, we employed carbohydrate intake as a potential confounder in the logistic analysis, in which carbohydrate and fat were simultaneously chosen as potential confounders.

To determine the relationships between fruit and/or vegetable intakes and MetS and its components, odds ratios (ORs) and 95% confidence intervals (95% CIs) was estimated by multivariate logistic analysis (PROC SURVEYLOGISTIC). Data analyses were performed with SAS 9.2 (SAS Institute Inc., Cary, NC).

RESULTS

General characteristics of the sample population

The average age was 49 years, and the average length of education was 10 years. Only 30% of the population exercised regularly, and current alcohol or cigarette users accounted for 28% and 4.6%, respectively. Women who currently used estrogen or were postmenopausal represented 12.5% and 39% of the total sample, respectively (Table 1).

Prevalence of MetS and its components

The prevalence of MetS was 15.9%, and its feature of low HDL-cholesterol had the highest prevalence (43.7%), followed by central obesity (23.0%), high BP (21.2%), high TG (19.7%) and high FPG (19.4%). When the women were divided by menopausal status (Figure 1), post-

Table 1. General characteristics of the study population

	Women (n=2,999)
General characteristics	
Age (year)	49.1±0.14
Education level (year)	10.4±0.12
Household income (%)[†]	289±11.6
Living w/ spouse (%)	84.8
Current Smoker (%)	4.6
Current alcohol drinker (%)	28.3
Regular exercise (%)	29.2
Body mass index (kg/m^2)	23.6±0.07
Multivitamin use (%)	25.2
Current estrogen use (%)	12.5
Menopausal status (%)	39.3
Dietary intake	
Energy intake (kcal)	1638±13.4
Carbohydrate intake (g/d)[‡]	274±1.17
Fat intake (g/d)[‡]	26.8±0.03
Sodium intake (mg)[‡]	4195±50.2
Total fruits and vegetables	563±9.2
Sufficient daily intake of total FV (≥500 g/d)	53.7
Total vegetables	325±4.9
Total vegetables minus Kimchi	203±4.1
Total fruits	237±7.9
Sufficient daily intake of total fruits (≥100 g/d)	47.4

All values are presented as weighted Mean± SE or weighted % as appropriate.
[†]Household income was represented as the poverty index ratio based on poverty threshold of each year (household income/ national poverty line × 100).
[‡]Nutrient intake was adjusted for total energy intake by the residual method.

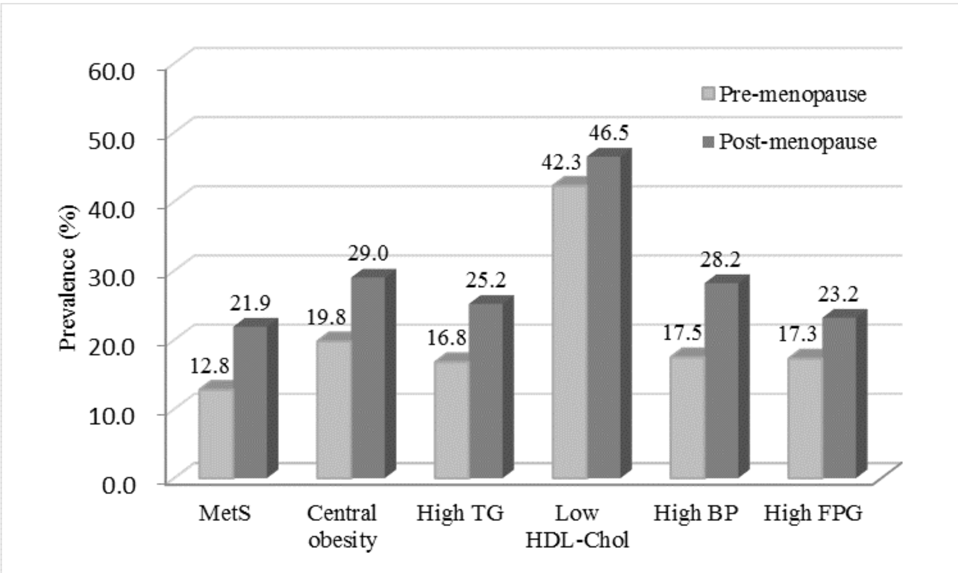

Figure 1. Prevalence of metabolic syndrome (MetS) and its components in women according to menopausal status. All estimates were obtained using the sample weight.

menopausal women were about twice as likely as premenopausal women to have MetS and the disorder of hypertension, central obesity and high TG.

When the risks of MetS and its components were analyzed by tertiles of daily fruit and/or vegetable intake, increased intake of FV was associated with decreased proportion of MetS, central obesity, high TG and high BP (Table 2). Despite no association of total vegetables with MetS or its disorders, higher intakes of total vegetables without kimchi were related to decreased risk of MetS and central obesity. Total fruit intake was inversely associated with the proportions of MetS, high TG and high BP

Selection of potential confounding factors

Potential related factors of MetS and its components were analyzed by tertiles of daily fruit and/or vegetable intake to identify potential confounding factors (Table 2). The total intake of FV and fruits increased with years of education, household income (poverty line, %), living with spouse, current smoker, and intake of energy, carbohydrate, and sodium, while vegetable intake, regardless of Kimchi inclusion increased with years of education, intake of energy, fat and sodium. Factors with p-value <0.05 in univariate analysis were entered into the final multiple logistic regression as confounders.

Adjusted ORs (95% CIs) of MetS and its components in total women

Total FV was inversely associated with the risk of MetS, high TG, and low HDL-cholesterol (Table 3). When we analyzed sufficient total FV intake (more than 500 grams daily according to the WHO and national recommendations), the association showed lower risks of MetS, high TG and low HDL-cholesterol. Subjects having a greater intake of vegetables, regardless of Kimchi intake, had a reduced risk of MetS compared with those having lower consumption, while those with greater fruit intake had a lower risk of high BP.

Adjusted ORs (95% CIs) of MetS and its components by menopausal status

In pre-menopausal women, total FV and vegetable intakes without Kimchi were marginally associated with central obesity, while fruit intake showed an inverse association with the risk of high BP (aOR=0.54, 95% CI=0.37-0.79, *p*-trend=0.004) (Table 4). Meanwhile, in post-menopausal women, total FV and total vegetable intakes, regardless of inclusion of Kimchi, were inversely associated with a risk of MetS (aOR=0.54, 95% CI=0.35-0.85, *p*-trend=0.007 for total FV and aOR=0.47, 95% CI=0.29-0.75, *p*-trend=0.003 for total vegetables) (Table 5). Furthermore, subjects having a greater intake of vegetables or more than 500 grams of daily FV intake had a reduced risk of high TG.

DISCUSSION

The associations of total fruit and/or vegetable intakes with the risk of MetS and its components by menopausal status were evaluated in Korean women aged 40-64 years using Korean national survey data. While total fruits intake was associated with a reduced risk of high BP, total vegetable and total FV intake was inversely associated with the risk of MetS and its features of high TG and low HDL-cholesterol. After women were divided by menopausal status, the association with the MetS risk was found only in post-menopausal women. With regard to its features, while the inverse associations of total vegetable or total FV intakes were observed with the risk of high TG in postmenopausal women, fruit intake was inversely associated with high BP in premenopausal women. Therefore, these findings suggest that while fruit intake is inversely associated with high BP apparently in premenopausal women, greater dietary intake of vegetables and total FV, as recommended for the prevention of CVD and diabetes, also can protect against the risk of MetS in women, particularly in postmenopausal women.

In this study, a lower risk of MetS was not related to fruit intake but vegetable intake. This result is consistent with the results of the Dose Responses to Exercise Training (DR's EXTRA) study, a population-based randomized control study of Finnish women aged 57-78 years. The study showed an inverse association of the vegetable intake (particularly non-root vegetables), but not fruits, on the MetS risk, although the inverse relation seemed to be attenuated after additional adjustment for energy intake.[21] As most of the women in that study were likely to be postmenopausal, these findings supported our results showing a stronger inverse association of vegetables in postmenopausal women. Meanwhile, a study of Tehranese women aged 40-60 years showed that women in the highest quintile of fruit and vegetable intake had a 34% and 30% lower chance, respectively, of having MetS, compared with those in the lowest quintile.[21] When fruit and vegetable intakes were combined, the inverse association became even stronger, in accordance with our results, although fruits were not inversely associated in our study. Furthermore, as FV consumption of at least 500 grams per day showed an inverse relation with MetS risk, the result supported the WHO and national definitions of adequate FV intake as at least 500 grams per day to prevent against chronic diseases.

With regard to the features of MetS, the study of Tehranese women revealed an inverse association of either fruit or vegetable intake with the risk of all of the MetS features except low HDL-cholesterol. In our study, fruit and vegetable intakes were related to a lower risk of elevated BP and elevated TG, respectively. The discrepancy in results may be due to differences in the types and amounts of FV consumed and the definition and prevalence of MetS and its features. Korean women generally have high intakes of vegetables (359 and 238 grams of vegetables and fruits, respectively), while the Tehranese women consumed (186 and 228 grams of vegetables and fruits, respectively). In addition, some diagnostic criteria of the components of MetS were different: central obesity was defined as a waist circumference ≥80 cm in this study and >88 cm in the Tehranese study, and elevated blood glucose level was defined as ≥100 mg/dL and ≥110 mg/dL, respectively.

The inverse association of higher consumption of total FV and vegetables with the risk of MetS and hypertriglyceridemia may be linked to the potential effects of phytochemicals, such as antioxidants[9] and phytoestrogens.[22] Firstly, high antioxidant intake is one possible factor that attenuates the development of MetS[9,23] and its components[9,10] through the modification of lipid and carbohydrate metabolism and increased insulin sensitivity.[24] This is supported by studies showing that MetS patients have elevated oxidative stress and reduced antioxidant protection compared with those without MetS,[10] and MetS patients showing inverse correlations between serum levels of antioxidants (such as SOD, GSH-Px and beta-carotene) and several factors including the number of MetS components, dietary fat intake, and energy intake.[23] Next, the reason why the inverse association in postmenopausal women was found in vegetables rather than fruits can be because most food sources rich in phytoestrogens in Korean diet are vegetables, such as soybeans (for example, tofu, bean sprout, beans) and mushrooms. The significant inverse association may be partly due to phytoestrogens having anti-estrogenic effects, induction of metabolic detoxification,[25] and lipid-lowering effects.[22] It could have been hypothesized that, while estrogen receptors in premenopausal women are more highly occupied with endogenous estradiol, phytoestrogens in postmenopausal women demonstrate estrogenic activity to replace the deficient estradiol. Therefore, postmenopausal women may potentially benefit more from higher phytoestrogen exposure than do premenopausal women.[26]

Furthermore, when interpreting the results of vegetable

Table 2. Selected characteristics according to tertiles of total fruit and/or vegetable intake

	Total FV			*p*-trend	Total vegetables			*p*-trend	Total vegetables-Kimchi			*p*-trend	Total fruits			*p*-trend
	T1	T2	T3		T1	T2	T3		T1	T2	T3		T1	T2	T3	
Amounts (N=2049)																
Metabolic syndrome (%)	18.5	17.2	14.4	0.020	16.7	17.2	17.2	0.627	19.0	16.4	14.1	0.008	20.3	15.3	14.8	0.018
Central obesity (%)	26.2	23.5	21.9	0.048	25.5	22.6	23.2	0.260	26.3	22.7	22.2	0.056	26.9	21.6	23.3	0.309
High Triglyceride (%)	22.5	20.3	17.9	0.019	21.4	18.7	20.7	0.685	22.6	18.1	19.9	0.215	23.5	19.6	17.9	0.010
Low HDL-Cholesterol (%)	45.6	45.2	41.1	0.069	44.5	42.3	45.3	0.771	46.0	42.9	42.6	0.196	43.7	45.9	42.5	0.420
High Blood Pressure (%)	24.8	21.9	19.8	0.017	24.1	20.6	21.5	0.234	22.9	23.6	19.9	0.110	26.3	21.2	19.5	0.009
High Fasting Plasma Glucose (%)	19.1	20.2	20.6	0.475	18.7	19.9	21.9	0.105	19.2	19.2	21.7	0.230	20.8	19.6	19.3	0.516
Age (year)	49.2	49.0	49.2	0.970	49.2	49.1	49.1	0.511	49.2	49.0	49.0	0.917	49.1	49.0	49.3	0.345
Education level (year)	9.6	10.4	10.5	<0.0001	9.9	10.4	10.3	0.048	9.7	10.4	10.5	<0.0001	9.3	10.4	10.7	<0.0001
Household income (poverty, %)†	249	319	296	0.003	265	319	280	0.274	266.2	289.9	311.0	0.115	242	318	299	0.015
Living w/ spouse (%)	81.2	85.7	86.0	0.014	83.1	83.4	86.9	0.031	81.9	86.5	84.6	0.183	79.7	86.8	86.0	0.016
Current Smoker (%)	7.0	3.6	2.4	0.0001	5.08	3.94	4.05	0.403	5.8	3.6	3.6	0.082	8.4	2.3	2.6	0.0003
Current alcohol drinker (%)	28.0	29.6	24.7	0.119	27.1	27.4	28.1	0.646	27.4	26.7	28.4	0.638	31.7	26.9	24.0	0.003
Regular exercise (%)	27.9	29.6	30.2	0.352	29.2	28.5	30.0	0.734	30.0	28.8	28.5	0.530	27.3	29.3	30.9	0.141
Body mass index (kg/m^2)	23.6	23.5	23.7	0.387	23.6	23.5	23.7	0.223	23.7	23.5	23.6	0.718	23.9	23.3	23.6	0.684
Multivitamin use (%)	22.7	26.3	27.4	0.064	24.7	26.3	25.3	0.795	24.4	25.6	26.5	0.377	19.4	27.6	29.0	0.001
Current estrogen use (%)	11.8	11.2	14.6	0.058	10.7	14.0	13.4	0.090	10.7	13.3	14.1	0.045	11.8	12.2	13.5	0.286
Menopausal status (%)	40.1	40.2	37.7	0.123	39.1	39.9	39.0	0.999	40.0	39.3	38.5	0.421	40.8	40.3	37.0	0.012
Energy intake (kcal)	1378	1619	1936	<0.0001	1396	1685	1934	<0.0001	1406	1659	1913	<0.0001	1520	1562	1818	<0.0001
Carbohydrate intake (g/d) ‡	266	275	286	<0.0001	273	280	273	0.846	277	280	267	<0.0001	269	267	290	<0.0001
Fat intake (g/d) ‡	25.8	27.4	25.9	0.883	25.3	26.5	27.9	0.0003	24.4	26.0	29.5	<0.0001	25.8	28.8	24.5	0.0003
Sodium intake (mg) ‡	3666	4387	4506	<0.0001	3298	4352	5269	<0.0001	3764	4236	4634	<0.0001	4262	4365	3881	<0.0001

All values except age were age-adjusted and weighted mean ± SE or weighted % were presented as appropriate.
†Household income was represented as the poverty index ratio based on poverty threshold of each year (household income/ national poverty line × 100).
‡Nutrient intakes were adjusted for total energy intake by the residual method.

Table 3. Multivariate adjusted odds ratios (95% CIs) for metabolic syndrome (MetS) and its components according to the tertiles of total fruit and/or vegetable intake

	Total Women					
	MetS	Central obesity	High TG	Low HDL-chol	High BP	High FPG
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Amount (g/d)						
Total fruits and vegetables (FV)†						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.92 (0.69, 1.17)	0.91 (0.71, 1.16)	0.90 (0.69, 1.17)	0.96 (0.77, 1.19)	0.86 (0.65, 1.14)	1.06 (0.82, 1.37)
T3	0.65 (0.47, 0.91)	0.80 (0.60, 1.06)	0.73 (0.54, 0.98)	0.78 (0.62, 0.99)	0.77 (0.57, 1.04)	1.15 (0.86, 1.55)
p-trend	0.009	0.112	0.031	0.031	0.097	0.351
Sufficient FV intake†						
<500 g/d	1.00	1.00	1.00	1.00	1.00	1.00
≥500 g/d	0.72 (0.55, 0.95)	0.87 (0.70, 1.09)	0.74 (0.58, 0.95)	0.81 (0.67, 0.98)	0.83 (0.65, 1.06)	1.10 (0.87, 1.38)
p-value	0.0182	0.2313	0.0193	0.0311	0.1265	0.4416
Total vegetables ‡						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.83 (0.61, 1.13)	0.85 (0.66, 1.11)	0.80 (0.61, 1.04)	0.95 (0.78, 1.17)	0.80 (0.62, 1.05)	1.03 (0.78, 1.34)
T3	0.72 (0.52, 1.00)	0.81 (0.61, 1.07)	0.81 (0.61, 1.08)	1.12 (0.88, 1.44)	0.86 (0.63, 1.17)	1.11 (0.84, 1.46)
p-trend	0.064	0.148	0.172	0.302	0.367	0.463
Vegetables without Kimchi§						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.82 (0.62, 1.08)	0.87 (0.69, 1.09)	0.74 (0.58, 0.95)	0.91 (0.74, 1.12)	1.08 (0.85, 1.36)	1.03 (0.78, 1.36)
T3	0.59 (0.44, 0.81)	0.80 (0.62, 1.03)	0.77 (0.59, 1.02)	0.94 (0.75, 1.17)	0.86 (0.66, 1.13)	1.13 (0.85, 1.51)
p-trend	0.0008	0.091	0.086	0.601	0.241	0.377
Total fruits¶						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.78 (0.58, 1.05)	0.85 (0.67, 1.09)	0.88 (0.68, 1.15))	1.13 (0.92, 1.38)	0.79 (0.62, 1.02)	0.93 (0.72, 1.21)
T3	0.79 (0.59, 1.07)	0.99 (0.76, 1.28)	0.85 (0.65, 1.12))	0.95 (0.75, 1.20)	0.70 (0.52, 0.94)	1.03 (0.78, 1.37)
p-trend	0.240	0.815	0.315	0.392	0.038	0.700
Sufficient fruits intake¶						
<200 g/d	1.00	1.00	1.00	1.00	1.00	1.00
≥200 g/d	0.84 (0.65, 1.08)	1.03 (0.82, 1.29)	0.89 (0.71, 1.13))	0.85 (0.70, 1.04)	0.86 (0.67, 1.10)	0.99 (0.78, 1.25)
p-value	0.178	0.797	0.350	0.116	0.223	0.924

†Adjusted for age, education level (years), household income (%), living with spouse (y, n), current smoker (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted sodium intake (mg/d).
‡Adjusted for age, education level (years), living with spouse (y/n), energy intake (kcal/d), energy-adjusted fat intake (g/d), energy-adjusted sodium intake (mg/d).
§Adjusted for age, education level (years), current estrogen use (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted sodium intake (mg/d).
¶Adjusted for age, education level (years), household income (%), living w/ spouse (y/n), current smoker (y/n), current alcohol drinker (y/n), multivitamin use (y/n), menopausal status (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted Sodium intake (mg/d).

Table 4. Multivariate adjusted odds ratios (95% CI) for metabolic syndrome (MetS) and its components according to tertiles of total fruit and/or vegetable intake in premenopausal women

	Premenopausal women					
	MetS	Central obesity	High TG	Low HDL-chol	High BP	High FPG
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Amount (g/d)						
Total fruits and vegetables (FV)[†]						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.91 (0.62, 1.34)	0.82 (0.58, 1.16)	0.99 (0.69, 1.41)	0.99 (0.75, 1.31)	0.82 (0.56, 1.18)	1.08 (0.75, 1.55)
T3	0.75 (0.48, 1.16)	0.69 (0.48, 1.00)	0.75 (0.51, 1.10)	0.81 (0.60, 1.10)	0.71 (0.48, 1.06)	1.06 (0.71, 1.59)
p-trend	0.187	0.047	0.118	0.147	0.101	0.809
Sufficient FV intake[†]						
<500 g/d	1.00	1.00	1.00	1.00	1.00	1.00
≥500 g/d	0.81 (0.57, 1.16)	0.81 (0.60, 1.09)	0.79 (0.58, 1.08)	0.81 (0.64, 1.03)	0.73 (0.53, 1.01)	1.05 (0.77, 1.44)
p-value	0.250	0.173	0.132	0.088	0.055	0.762
Total vegetables[‡]						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	1.32 (0.85, 2.03)	0.80 (0.57, 1.14)	1.08 (0.76, 1.54)	1.10 (0.84, 1.43)	0.95 (0.66, 1.37)	1.24 (0.86, 1.79)
T3	1.01 (0.64, 1.62)	0.73 (0.51, 1.04)	0.97 (0.66, 1.43)	1.22 (0.91, 1.65)	1.04 (0.68, 1.58)	1.26 (0.85, 1.88)
p-trend	0.968	0.086	0.895	0.173	0.848	0.267
Vegetables without Kimchi[§]						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.86 (0.58, 1.27)	0.84 (0.61, 1.15)	0.76 (0.54, 1.07)	0.99 (0.77, 1.29)	1.14 (0.81, 1.60)	0.97 (0.68, 1.38)
T3	0.67 (0.43, 1.04)	0.71 (0.51, 0.98)	0.84 (0.58, 1.22)	1.03 (0.78, 1.37)	0.90 (0.61, 1.34)	1.20 (0.83, 1.73)
p-trend	0.072	0.040	0.418	0.817	0.559	0.307
Total fruits[¶]						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.67 (0.44, 1.03)	0.98 (0.71, 1.36)	0.84 (0.59, 1.18)	0.98 (0.75, 1.27)	0.72 (0.52, 1.01)	0.89 (0.63, 1.26)
T3	0.87 (0.58, 1.30)	1.01 (0.73, 1.40)	0.79 (0.55, 1.14)	0.98 (0.72, 1.33)	0.54 (0.37, 0.79)	0.97 (0.67, 1.42)
p-trend	0.82	0.927	0.281	0.927	0.004	0.984
Sufficient fruits intake[¶]						
<200 g/d	1.00	1.00	1.00	1.00	1.00	1.00
≥200 g/d	0.9 (0.63, 1.29)	1.03 (0.78, 1.36)	0.82 (0.59, 1.14)	0.87 (0.68, 1.13)	0.63 (0.46, 0.87)	0.93 (0.67, 1.29)
p-value	0.576	0.819	0.247	0.296	0.005	0.672

[†]Adjusted for age, education level (years), household income (%), living with spouse (y,n), current smoker (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted sodium intake (mg/d). [‡]Adjusted for age, education level (years), living with spouse (y/n), energy intake (kcal/d), energy-adjusted fat intake (g/d), energy-adjusted sodium intake (mg/d). [§]Adjusted for age, education level (years), current estrogen use (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted Sodium intake (mg/d). [¶]Adjusted for age, education level (years), household income (%), living w/ spouse (y/n), current smoker (y/n), current alcohol drinker (y/n), multivitamin use (y/n), menopausal status (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted sodium intake (mg/d).

Table 5. Multivariate adjusted odds ratios (95% CI) for metabolic syndrome (MetS) and its components according to the tertiles of total fruit and/or vegetable intake in postmenopausal women

	Postmenopausal women					
	MetS	Central obesity	High TG	Low HDL-chol	High BP	High FPG
	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Amount (g/d)						
Total fruits and vegetables (FV)[†]						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.88 (0.61, 1.27)	1.07 (0.75, 1.53)	0.80 (0.55, 1.17)	0.91 (0.63, 1.31)	0.90 (0.61, 1.33)	1.04 (0.70, 1.54)
T3	0.54 (0.35, 0.85)	1.02 (0.66, 1.56)	0.70 (0.45, 1.08)	0.72 (0.49, 1.08)	0.83 (0.54, 1.27)	1.28 (0.81, 2.00)
p-trend	0.007	0.984	0.118	0.104	0.402	0.265
Sufficient FV intake[†]						
<500 g/d	1.00	1.00	1.00	1.00	1.00	1.00
≥500 g/d	0.62 (0.43, 0.91)	0.99 (0.71, 1.39)	0.69 (0.48, 1.00)	0.80 (0.59, 1.09)	0.95 (0.67, 1.35)	1.15 (0.80, 1.66)
p-value	0.015	0.934	0.046	0.164	0.777	0.445
Total vegetables[‡]						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.45 (0.29, 0.70)	0.97 (0.65, 1.44)	0.49 (0.33, 0.72)	0.73 (0.52, 1.02)	0.64 (0.43, 0.96)	0.75 (0.50, 1.12)
T3	0.47 (0.29, 0.75)	0.97 (0.61, 1.55)	0.60 (0.38, 0.94)	0.94 (0.62, 1.43)	0.62 (0.37, 1.02)	0.89 (0.55, 1.44)
p-trend	0.003	0.913	0.046	0.864	0.070	0.684
Vegetables without Kimchi[§]						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.76 (0.51, 1.16)	0.93 (0.66, 1.31)	0.70 (0.48, 1.04)	0.77 (0.54, 1.08)	0.98 (0.69, 1.40)	1.12 (0.72, 1.74)
T3	0.50 (0.32, 0.78)	0.96 (0.63, 1.45)	0.68 (0.44, 1.05)	0.78 (0.53, 1.14)	0.77 (0.49, 1.20)	1.03 (0.65, 1.63)
p-trend	0.002	0.860	0.099	0.222	0.234	0.931
Total fruits[¶]						
T1	1.00	1.00	1.00	1.00	1.00	1.00
T2	0.89 (0.58, 1.35)	0.69 (0.48, 0.99)	0.94 (0.64, 1.37)	1.45 (1.02, 2.05)	0.91 (0.63, 1.32)	1.01 (0.66, 1.55)
T3	0.68 (0.43, 1.08)	0.96 (0.64, 1.44)	0.93 (0.61, 1.43)	0.89 (0.63, 1.26)	0.95 (0.62, 1.46)	1.09 (0.68, 1.74)
p-trend	0.097	0.700	0.805	0.137	0.917	0.708
Sufficient fruits intake[¶]						
200 g/d	1.00	1.00	1.00	1.00	1.00	1.00
≥200 g/d	0.77 (0.53, 1.11)	1.05 (0.75, 1.48)	1.01 (0.70, 1.44)	0.82 (0.61, 1.09)	1.2 (0.85, 1.70)	1.04 (0.72, 1.50)
p-value	0.155	0.766	0.979	0.174	0.296	0.826

[†]Adjusted for age, education level (years), household income (%), living with spouse (y,n), current smoker (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted sodium intake (mg/d). [‡]Adjusted for age, Education level (years), living with spouse (y/n), energy intake (kcal/d), energy-adjusted fat intake (g/d), energy-adjusted sodium intake (mg/d). [§]Adjusted for age, education level (years), current estrogen use (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted sodium intake (mg/d). [¶]Adjusted for age, education level (years), household income (%), living w/ spouse (y/n), current smoker (y/n), current alcohol drinker (y/n), multivitamin use (y/n), nenopausal status (y/n), energy intake (kcal/d), energy-adjusted carbohydrate intake (g/d), energy-adjusted sodium intake (mg/d).

intakes, consideration should be given to the Korean diet pattern, which is rice-based and characterized by a relatively low intake of fat and a high intake of vegetables.[18] Although vegetable intake without Kimchi was limited to a reduced risk of central obesity in premenopausal women, in postmenopausal women total vegetable intake including Kimchi showed the reduced risk of elevated TG as well as MetS. This may be explained partly by the fact that Kimchi is a rich source of fibre and vitamins, such as carotenoids and vitamin C, which can have positive impacts on health, such as hypocholesterolemic and anticancer effects.[27] Secondly, among the features of MetS, elevated TG risk was more highly associated than other features, as it was inversely associated with vegetable intake. This finding is supported by a previous study reporting that the intake of low-fat, high-carbohydrate and high-fiber foods, similar to those in the Korean diet, was associated with low serum TG level.[28] Next, the inverse association of vegetable intake and the total FV intake vanished or became weaker when sodium intake was excluded as a confounder in the analysis (data not shown). This result is supported by previous data showing that high rice or salt consumption was related to an increased risk of low HDL-cholesterol level[29] or high BP.[30] Therefore, considering that the sodium intake of the Korean population is higher than the recommended intake[31] and is related to the high prevalence of chronic diseases such as hypertension and stroke,[32] public health efforts should be continued in the Korean population to reduce salt intake while retaining the traditional Kimchi consumption.

This study has a limitation, which is that the FV intakes were assessed by a single 24-hour recall. Although the interviewers sought to obtain a consistent amount of information at each interview, it is difficult to ascertain how accurately food intake was measured using one-day recall to reflect the usual intake among Korean adults.[19] However, not many studies have been done on the direct association between FV consumption and metabolic syndrome and furthermore, no study to date has investigated the association stratified by menopausal status using large representative population surveys. Meanwhile, as it's possible that the women with the diagnosis of high BP, MetS or high TG and low HDL cholesterol had changed their nutritional habits before the study and the results can be an inverse causality phenomena, we excluded subjects with histories of diseases, such as CVD and diabetes or taking medications related to hypertension or diabetes before analysis. Therefore, the influence of health behavior changes due to the disease has been lessened.

In conclusion, while higher fruit intake was inversely associated with hypertension among premenopausal women, greater vegetable intake and total FV intake reduced the risk of MetS and elevated TG, particularly among postmenopausal women. This study supports a potential benefit role of FV consumption in the prevention of MetS, particularly among postmenopausal women and further longitudinal studies are warranted to elucidate the associations.

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AUTHOR DISCLOSURES

There is no conflict of interest to declare.

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