

## Original Article



# Association between Total Diet Quality and Metabolic Syndrome Incidence Risk in a Prospective Cohort of Korean Adults

Saerom Shin, Seungmin Lee

Department of Food and Nutrition, Sungshin Women's University, Seoul, Korea

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### Correspondence to Seungmin Lee

Department of Food and Nutrition, Sungshin Women's University, 55 Dobong-ro 76ga-gil, Gangbuk-gu, Seoul 01133, Korea.

E-mail: smllee@sungshin.ac.kr

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### ORCID iDs

Seungmin Lee

<https://orcid.org/0000-0003-3046-8010>

### Conflict of Interest

The authors declare that they have no competing interests.

## ABSTRACT

The purpose of this study was to prospectively investigate the relation between total diet quality and metabolic syndrome in Korean adults. A community-based cohort of the Korean Genome and Epidemiology Study (KoGES) provided basis for this study. During the total follow-up period of 38,171 person-years of 5,549 subjects, a total of 1,891 metabolic syndrome incident cases were identified. Metabolic syndrome was defined by the criteria of the National Cholesterol Education Program Adult Treatment Panel. Mediterranean Diet Score (MDS), Dietary Approaches to Stop Hypertension diet, and Recommended Food Score (RFS) were used to assess total diet quality. Cox proportional hazards regression was used to estimate hazard ratios (HRs) for metabolic syndrome associated with total diet quality. In men, the incidence of metabolic syndrome in the 5th MDS quintile group decreased by approximately 25% compared to the 1st quintile group ( $p$  for trend  $< 0.01$ ) after adjusting for age and energy intake. In women, significant decreasing trend of metabolic syndrome incidence risk was observed across the quintiles of RFS in an age and energy intake-adjusted model (HR [95% CI] of Q5 vs. Q1; 0.662 [0.521–0.842],  $p$  for trend  $< 0.01$ ). However, such associations did not reach at a significance level when additional covariates were included. In this first study looking at prospective relation of metabolic syndrome with total diet quality in a Korean population, study findings suggest some protective role of better diet quality in preventing future metabolic syndrome. But no convincing evidence was observed in this study.

**Keywords:** Diet; Metabolic syndrome; Incidence

## INTRODUCTION

In Korea rapid lifestyle changes and aging makes chronic diseases major causes of morbidity and mortality. According to the Korean National Health and Nutrition Examination Survey in 2014, the prevalence of chronic diseases among Korean adults aged 30 years and higher is 36.5%, 32.0%, 10.6%, 19.5%, and 16.8% for obesity, hypertension, diabetes, hypercholesterolemia, and hypertriglycemia, respectively [1]. The metabolic syndrome which displays multiple metabolic risk factors in a person was found to be approximately 31%. The prevalence of hypercholesterolemia, pre-diabetes, obesity, hypertension, and hyperlipidemia is steadily increasing over the past decade, and the prevalence of metabolic syndrome is expected to increase in the future.

Galassi et al. [2] reported that the metabolic syndrome increases cardiovascular disease and cardiovascular disease mortality by 2.34-fold and 2.40-fold, respectively. In addition, as the number of risk factors for metabolic syndrome increments, the risk of cardiovascular disease increases proportionally. Metabolic syndrome is, thus, considered to be a more potent factor for predicting cardiovascular disease risk than any single metabolic risk factor [3]. Obesity, hypertension, diabetes and hypercholesterolemia can be seen as precedents of cardiovascular diseases. It is reported that proper management of these preceding conditions can prevent leading to serious diseases such as myocardial infarction or stroke up to 80% [4].

On the other hand, the secular trend of dietary factors associated with the risk of metabolic syndrome seems worrying in Korea. The proportion of exceeding the estimated average requirement of energy intake was 37.9% in 1998 and increased by 5.9% point in 2014 (43.8%) [1]. Simple sugar intake including sugar, starch syrup, candy, chocolate, and other sugars were 12.8 g/day, which was the highest since 1998 (7.3 g/day). The proportion of eating-out more than once a day increased by 1.5 times to 32.4% in 2014 compared to 24.2% in 2008, and those with higher eating-out frequency consumed more energy, fat, and sodium. Although sodium intake has been decreasing, about 80% of the population still consume more than the target intake level of 2,000 mg/day.

There is limitation in understanding the whole context of disease risk with a single nutrient or food group, especially in a case that the disease is associated with multiple dietary factors. It is reasonable and attractive venue to examine overall diet's role in disease risk, and a large body of research employed this approach in understanding prevention and management of chronic diseases [5-9]. The association of metabolic syndrome with antioxidant vitamins, fat, cholesterol, dairy products, fish, alcohol, and meat has been reported in Korea [10-15]. While the cross-sectional relation between total diet and metabolic syndrome has been studied in a Korean population [16], there is a lack of longitudinal studies on it. The purpose of this study was to investigate the relation between overall dietary quality and incidence risk of metabolic syndrome in Korean adults based on a community-based cohort population.

## MATERIALS AND METHODS

### Subjects

We used community-based cohort (Ansan-Anseong cohort) data of the Korean Genome and Epidemiology Study (KoGES). Data from the baseline in 2001 up to the follow-up survey in 2014 was used for this study. The KoGES is a nation-led cohort project conducted every 2 years from 2001 with the aim of identifying the environmental and genetic risk factors of chronic diseases, identifying interactions among them, and establishing guidelines for disease prevention [17]. The Ansan-Anseong cohort is a large-scale cohort of 40 to 69-year-old general population, and it collect blood, urine, and genomic biological samples and information on health, lifestyle, diet, and environmental factors.

Of the 10,030 participants who responded to basic health examination and food frequency questionnaire in the baseline survey, those previously diagnosed with metabolic syndrome ( $n = 2,374$ ) or diet-related chronic diseases ( $n = 1,614$ ) and those aged less than 40 or over 69 years ( $n = 284$ ) were excluded. Subjects with no blood sample ( $n = 99$ ), no dietary data ( $n = 42$ ), or reported daily energy intake less than 500 kcal or higher than 5,000 kcal were also excluded. Finally, data from a total of 5,549 subjects (2,805 men and 2,744 women)

were analyzed for this study. During the total follow-up period of 38,171 person-years (mean follow-up, 6.9 years), a total of 1,891 metabolic syndrome incident cases were identified.

### Diagnostic criteria for metabolic syndrome

Metabolic syndrome was defined by the criteria of the National Cholesterol Education Program Adult Treatment Panel [3]. For a central obesity component, a waist circumference cutoff suggested by the Korean Society for the Study of Obesity was used (> 90 cm for men, > 85 cm for women) [18]. Those taking medicine for metabolic syndrome components were counted as having the corresponding risk factors of metabolic syndrome.

### Evaluation of total diet quality

Dietary data was collected using a semi-quantitative food frequency questionnaire (SQFFQ) with 103 items which was developed and validated among Korean adults [19]. Considering the fact that there is no single absolute measurement for total diet quality, this study utilized 3 indexes including Mediterranean Diet Score (MDS), Dietary Approaches to Stop Hypertension (DASH), and Recommended Food Score (RFS) to assess total diet quality. The MDS includes components of vegetables, nuts and legumes, fruits, whole grains, fish, potatoes, meat, sweetened beverages, olive oil, butter, and alcohol [20]. The DASH diet consists of vegetables, nuts and legumes, fruits, whole grains, red meat, low fat dairy products, sweetened beverages, and sodium [21]. RFS is composed of fruits, vegetables, protein foods, grains, and dairy products [22]. We modified these indexes applicable to Korean diet and the SQFFQ data. **Table 1** displays index components and scoring scheme of MDS, DASH, and RFS for this study. Kimchi and pickles were not counted for the vegetable component, while seaweeds and mushrooms were included in the vegetable component.

### Statistical analysis

All data processing and statistical tests were analyzed using SAS 9.4 (SAS Institute, Cary, NC, USA). Categorical and continuous data were summarized by a frequency and percentage and a mean and standard deviation, respectively. To compare differences between men and women, the chi-square test for categorical variables and the independent t-test for continuous variables were conducted. Food group intakes across levels of total diet quality were compared by the generalized linear model adjusting for age (year) and total energy intake (kcal/day). Cox proportional hazards regression was used to estimate crude and adjusted hazard ratio (HR) for metabolic syndrome associated with total diet quality represented by MDS, DASH diet, and RFS. Covariates in the Cox regression analysis included age (years), energy intake (kcal/day), income (< 1; ≥ 1 and < 2; ≥ 2 and < 4; ≥ 4, unit of million Korean won), education (elementary school graduate or less; middle school; high school; college graduate or more), physical activity (metabolic equivalents; METs), smoking (pack-years), drinking (alcohol intake, g/day). Statistical significance was determined at a level of  $p < 0.05$ .

## RESULTS

### General characteristics

The distribution of subjects' general characteristics by gender is shown in **Table 2**. Significant differences between men and women were found in education level, income level, drinking and smoking status, and physical activity, but the average age was not different. The level of education and income was higher in men than in women. In men, 71.8% of subjects were drinkers, while 69.7% of women subjects reported no alcohol

**Table 1.** Overview of diet quality component and scoring scheme of MDS, DASH and RFS in this study

Index component	Scoring scheme		
	MDS	DASH	RFS
Vegetables	(+) 1 point ≥ 5rd quintile	(+) 1–5 point (except potatoes & legumes) 1–5 lowest to highest quintile	(+) 22 point (1 point for each food item) × 0.94 : green chilli, pepper leaves, spinach, lettuce, perilla leaf, chives/water parsley, green vegetables, daikon, balloon flower root/deodeok, onion, napa cabbage, cucumber, bean sprouts, carrot/carrot juice, pumpkin, green pumpkin, vegetable juices, bracken/sweet potato vines, oyster mushroom and others, laver, kelp/seaweed
Nut & legumes	(+) 1 point ≥ 5rd quintile	(+) 1–5 point 1–5 lowest to highest quintile	-
Fruits	(+) 1 point ≥ 5rd quintile	(+) 1–5 point 1–5 lowest to highest quintile	(+) 12 point (1 point for each food item) × 1.15 : persimmon/dried Persimmon, mandarin, oriental melon/melon, banana, pear, apple/apple juice, orange/orange juice, watermelon, peach/plum, strawberry, grape/grape juice, tomato/tomato juice
Whole grains	(+) 1 point ≥ 5rd quintile	(+) 1–5 point 1–5 lowest to highest quintile	(+) 3 point (1 point for each food item) × 3.0724 : barley rice, multi-grain rice, powder made of mixed grains
Fish	(+) 1 point ≥ 5rd quintile	-	-
Meats	(-) 1 point ≤ 1st quintile	(-) 1–5 point 1–5 highest to lowest quintile	-
Dairy products	(+) 1 point ≥ 5rd quintile	(+) 1–5 point 1–5 highest to lowest quintile	(+) 3 point (1 point for each food item) × 1.54 : milk, yogurt, cheese
Sugar sweetened beverages	(+) 1 point ≤ 1st quintile	(-) 1–5 point 1–5 highest to lowest quintile	-
Sodium	-	(-) 1–5 point 1–5 highest to lowest quintile	-
Oil	(+) 1 point	-	-
Alcohol	(+) 1 point 0.01–12 g/day	-	-
Protein foods	-	-	(+) 13 point (1 point for each food item) × 0.35 : bean/beans cooked in soy sauce, tofu, soybean paste soup/rich soybean paste stew, jellied food, peanut/almond/pine nut, chicken/drumstick/wings, egg/quail egg, sashimi, hairtail, eel, croaker, pollack /frozen pollack/dried pollack, external blue colored fish
Total score	10	40	53

MDS, Mediterranean Diet Score; DASH, Dietary Approaches to Stop Hypertension; RFS, Recommended Food Score.

consumption. An average daily alcohol intake was much higher in men ( $17.6 \pm 27.9$  g/day) compared to that in women ( $1.6 \pm 5.8$  g/day). Proportions of smokers were only 3.8% in women and 51.7% in men, and average pack-years were also significantly higher in men ( $18.0 \pm 17.6$  pack-years) than in women ( $0.4 \pm 2.6$  pack-years). In both men and women, a physical activity level less than 20 METs was most common in 57.3% and 96.2%, respectively. There was a significant gender difference in distribution of physical activity level.

### Nutrient and food group intakes according to total diet quality levels

**Tables 3** and **4** show comparison of daily food group intakes between the 1st and 5th quintiles of the three diet quality index scores in men and women. Most of the examined food group intakes differed significantly by the index score levels of MDS, DASH, and RFS. Overall, average intakes of whole grains, fruits, vegetables, dairy products, and nuts and legumes significantly increased across the lowest to highest quintile of the diet quality indexes in both men and women. On the contrary sugar sweetened beverage intakes were significantly lower in the highest quintiles than in the lowest quintiles. In terms of meats, however, changes across diet index quintiles were not consistent among the 3 indexes. It was significantly higher in the highest quintiles than in the lowest quintiles for the MDS and RFS indexes, but was somewhat lower in the highest quintiles than in the lowest quintiles for the DASH index.

**Table 2.** General characteristics of the subjects at baseline

Characteristics	Men (n = 2,805)	Women (n = 2,744)	p value
Age (yr)	50.8 ± 8.6	50.0 ± 8.5	NS
Education			*
Elementary school graduate or less	547 (19.6)	980 (35.9)	
Middle school graduate	631 (22.6)	697 (25.6)	
High school graduate	1,022 (36.6)	854 (31.3)	
College graduate or higher	594 (21.3)	197 (7.2)	
Income (million Korean won)			*
< 1	751 (27.0)	899 (33.5)	
≥ 1 and < 2	862 (31.0)	830 (30.9)	
≥ 2 and < 4	920 (33.1)	774 (28.8)	
≥ 4	250 (9.0)	182 (6.8)	
Drinking			*
Non-drinker	791 (28.2)	1,913 (69.7)	
Drinker	2,014 (71.8)	831 (30.3)	
Alcohol intake (g/day)	17.6 ± 27.9	1.6 ± 5.8	*
Smoking			*
Non-smoker	1,354 (48.3)	2,639 (96.2)	
Smoker	1,451 (51.7)	105 (3.8)	
Pack-year	18.0 ± 17.6	0.4 ± 2.6	*
Physical activity			*
20 > METs	1,560 (57.3)	1,787 (66.9)	
20 ≤ METs < 40	536 (19.7)	425 (15.9)	
40 ≤ METs	627 (23.0)	458 (17.2)	

Values are expressed as mean ± standard deviation or number (%).

NS, not significant; MET, metabolic equivalent.

\*p < 0.001 by  $\chi^2$  test or independent t-test.

**Table 3.** Food group intakes for selected quintiles of diet quality index scores in men

Dietary component	Diet quality index								
	MDS		p value	DASH		p value	RFS		p value
	1*	5		1	5		1	5	
Total index score	9.87 ± 2.05	24.41 ± 2.36	†	18.17 ± 1.83	29.69 ± 1.74	†	8.76 ± 2.28	32.92 ± 6.83	†
Food groups (servings/day)									
Whole grains	2.43 ± 5.95	14.86 ± 9.67	†	1.68 ± 4.80	15.48 ± 9.46	†	0.24 ± 0.43	1.09 ± 0.71	†
Fruits	4.45 ± 4.63	15.71 ± 13.81	†	5.64 ± 6.87	15.89 ± 14.16	†	0.47 ± 0.92	5.37 ± 3.59	†
Vegetables	16.09 ± 9.54	39.39 ± 19.40	†	19.71 ± 11.93	35.97 ± 19.34	†	2.68 ± 1.83	12.05 ± 4.30	†
Dairy products	1.52 ± 3.03	6.59 ± 5.48	†	1.87 ± 3.10	6.54 ± 5.39	†	0.34 ± 0.59	1.33 ± 0.86	†
Meats	1.52 ± 3.03	6.59 ± 5.48	†	5.46 ± 4.88	3.73 ± 3.10	†	0.45 ± 0.92	1.88 ± 1.85	†
Nuts & legumes	4.69 ± 3.93	14.55 ± 9.30	†	5.13 ± 3.75	14.47 ± 9.20	†	1.42 ± 0.94	2.78 ± 1.05	†
SSBs	12.33 ± 9.08	7.25 ± 7.41	†	13.96 ± 8.74	5.67 ± 6.53	†	0.91 ± 0.73	1.54 ± 0.92	†

Values are expressed as mean ± standard deviation.

MDS, Mediterranean Diet Score; DASH, Dietary Approaches to Stop Hypertension; RFS, Recommended Food Score; SSB, sugar-sweetened beverage.

\*Quintile of diet quality index score (a higher quintile indicates better diet quality); †p < 0.001 by generalized linear model adjusted for age(year) and energy intake(kcal/day).

**Table 4.** Food group intakes for selected quintiles of diet quality index scores in women

Dietary component	Diet quality index								
	MDS		p value	DASH		p value	RFS		p value
	1*	5		1	5		1	5	
Total index score	9.91 ± 1.94	24.14 ± 2.19	‡	18.32 ± 1.67	29.46 ± 1.59	‡	9.57 ± 2.53	36.49 ± 7.24	‡
Food groups (servings/day)									
Whole grains	4.77 ± 7.86	16.39 ± 9.37	‡	3.93 ± 7.21	17.00 ± 9.02	‡	0.39 ± 0.49	1.30 ± 0.67	‡
Fruits	6.26 ± 6.00	22.00 ± 20.12	‡	7.54 ± 8.27	20.04 ± 18.21	‡	0.68 ± 1.17	6.29 ± 3.42	‡
Vegetables	15.95 ± 10.67	44.78 ± 27.00	‡	20.24 ± 13.96	38.67 ± 25.93	‡	2.80 ± 1.98	11.75 ± 4.18	‡
Dairy products	2.02 ± 3.62	8.42 ± 6.44	‡	2.05 ± 3.31	7.72 ± 6.31	‡	0.40 ± 0.63	1.47 ± 0.84	‡
Meats	2.02 ± 3.62	8.42 ± 6.44	‡	3.76 ± 3.60	2.63 ± 3.38	‡	0.20 ± 0.54	1.37 ± 1.44	‡
Nuts & legumes	4.56 ± 4.27	15.51 ± 8.93	‡	4.84 ± 4.58	14.95 ± 8.81	‡	1.37 ± 0.94	2.63 ± 1.00	‡
SSBs	7.78 ± 7.27	4.61 ± 5.84	‡	9.01 ± 7.07	2.92 ± 4.41	‡	0.67 ± 0.64	1.06 ± 0.84	†

Values are expressed as mean ± standard deviation.

MDS, Mediterranean Diet Score; DASH, Dietary Approaches to Stop Hypertension; RFS, Recommended Food Score; SSB, sugar-sweetened beverage.

\*Quintile of diet quality index score (a higher quintile indicates better diet quality); †p < 0.01, ‡p < 0.001 by generalized linear model adjusted for age(year) and energy intake(kcal/day).

**Table 5.** Incidence risk of metabolic syndrome across quintiles of diet quality index scores in men

Diet quality index score quintiles	Range of scores	Crude				Model 1 <sup>†</sup>		Model 2 <sup>‡</sup>	
		No. of case	Total person-years	HR	95% CI	HR	95% CI	HR	95% CI
<b>MDS</b>									
1*	3–12	191	1,347,100	1.000		1.000		1.000	
2	13–15	199	1,394,021	1.004	0.823–1.224	0.966	0.791–1.180	1.026	0.831–1.266
3	16–18	197	1,480,813	0.939	0.769–1.146	0.891	0.728–1.090	0.930	0.749–1.153
4	19–21	181	1,344,345	0.948	0.774–1.162	0.862	0.697–1.065	0.952	0.759–1.194
5	22–33	180	1,468,716	0.862	0.703–1.056	0.757	0.609–0.942	0.862	0.681–1.091
p value for trend				NS		§		NS	
<b>DASH</b>									
1	11–20	202	1,502,887	1.000		1.000		1.000	
2	21–22	163	1,136,625	1.062	0.864–1.305	1.045	0.850–1.285	1.067	0.859–1.326
3	23–24	177	1,301,745	1.009	0.824–1.234	0.985	0.804–1.206	1.002	0.810–1.241
4	25–27	211	1,682,308	0.929	0.766–1.127	0.893	0.735–1.085	0.939	0.764–1.153
5	28–37	195	1,411,430	1.023	0.840–1.246	0.951	0.776–1.165	1.036	0.835–1.286
p value for trend				NS		NS		NS	
<b>RFS</b>									
1	3.42–11.78	194	1,392,513	1.000		1.000		1.000	
2	11.78–15.92	171	1,443,624	0.845	0.688–1.038	0.829	0.673–1.021	0.895	0.718–1.114
3	15.93–20.03	185	1,423,488	0.931	0.761–1.138	0.898	0.729–1.106	0.938	0.752–1.170
4	20.05–25.72	200	1,353,452	1.061	0.871–1.292	0.999	0.808–1.235	1.053	0.838–1.323
5	25.75–65.32	198	1,421,918	0.998	0.819–1.217	0.891	0.706–1.125	0.941	0.732–1.209
p value for trend				NS		NS		NS	

MDS, Mediterranean Diet Score; DASH, Dietary Approaches to Stop Hypertension; RFS, Recommended Food Score; HR, hazard ratio; CI, confidence interval; NS, not significant; MET, metabolic equivalent.

\*Quintile of diet quality index score (a higher quintile indicates better diet quality); <sup>†</sup>Model 1 adjusted for age (year) and total energy intake (kcal/day); <sup>‡</sup>Model 2 adjusted for age (year), total energy intake (kcal/day), income level (< 1; ≥ 1 and < 2; ≥ 2 and < 4; ≥ 4, million Korean won), education level (elementary school graduate or less; middle school; high school; college graduate or more), physical activity (METs), smoking (pack-years), drinking (total alcohol intake, g/day); <sup>§</sup>p for trend < 0.01 by Cox proportional hazards regression analysis.

### Incidence risk of metabolic syndrome in relation to total diet quality

**Table 5** presents incidence risk of metabolic syndrome in relation to total diet quality assessed by MDS, DASH, and RFS during the follow-up period in men. In the case of MDS, the incidence of metabolic syndrome in the 5th quintile group decreased by approximately 25% compared to the 1st quintile group (p for trend < 0.01) after adjusting for age and energy intake. However, this significant association was not kept in a multivariate-adjusted model with additional covariates. There were no significant differences in the incidence risk of metabolic syndrome across the levels of total diet quality represented by DASH and RFS.

**Table 6** presents incidence risk of metabolic syndrome in relation to total diet quality assessed by MDS, DASH, and RFS in women. No significant association was found between metabolic syndrome incidence and total diet quality assessed by MDS and DASH. Significant decreasing trend of metabolic syndrome incidence risk was observed across the quintiles of RFS in a crude analysis (HR [95% CI] of Q5 vs. Q1; 0.706 [0.578–0.861], p for trend < 0.01) and in a model adjusted for age and energy intake (0.662 [0.521–0.842], p for trend < 0.01). But this association disappeared in a model including additional covariates.

## DISCUSSION

The present study investigated the effect of total diet quality on the risk of developing metabolic syndrome-based community-based cohort data from the baseline in 2001 to the follow-up in 2014. Since total diet quality cannot be definitely defined by a single

**Table 6.** Incidence risk of metabolic syndrome across quintiles of diet quality index scores in women

Diet quality index score quintiles	Range of scores	Crude				Model 1 <sup>†</sup>		Model 2 <sup>‡</sup>	
		No. of case	Total person-years	HR	95% CI	HR	95% CI	HR	95% CI
<b>MDS</b>									
1*	2–12	183	1,354,548	1.000		1.000		1.000	
2	13–15	188	1,250,730	1.113	0.908–1.365	1.077	0.878–1.322	1.070	0.862–1.328
3	16–18	214	1,562,815	1.016	0.834–1.237	0.987	0.807–1.207	1.071	0.868–1.322
4	19–21	166	1,328,592	0.926	0.750–1.142	0.867	0.696–1.081	0.966	0.768–1.215
5	22–33	192	1,410,404	1.009	0.824–1.236	0.902	0.719–1.132	1.016	0.802–1.288
p value for trend				NS		NS		NS	
<b>DASH</b>									
1	11–20	175	1,348,174	1.000		1.000		1.000	
2	21–22	157	1,170,726	1.034	0.833–1.282	0.980	0.789–1.215	1.003	0.800–1.259
3	23–24	188	1,295,242	1.122	0.913–1.378	1.043	0.848–1.283	1.062	0.854–1.321
4	25–27	243	1,732,171	1.081	0.890–1.313	0.926	0.759–1.130	0.991	0.804–1.222
5	28–37	180	1,360,776	1.022	0.830–1.258	0.840	0.678–1.042	0.899	0.716–1.128
p value for trend				NS		NS		NS	
<b>RFS</b>									
1	3.42–13.10	224	1,264,143	1.000		1.000		1.000	
2	13.10–17.79	189	1,408,459	0.759	0.625–0.921	0.787	0.647–0.957	0.806	0.656–0.990
3	17.79–22.46	167	1,435,783	0.659	0.539–0.805	0.689	0.559–0.848	0.794	0.638–0.988
4	22.47–28.56	191	1,414,020	0.767	0.632–0.930	0.785	0.637–0.968	0.876	0.700–1.096
5	28.58–69.43	172	1,384,684	0.706	0.578–0.861	0.662	0.521–0.842	0.801	0.623–1.030
p value for trend				§		§		NS	

MDS, Mediterranean Diet Score; DASH, Dietary Approaches to Stop Hypertension; RFS, Recommended Food Score; HR, hazard ratio; CI, confidence interval; NS, not significant; MET, metabolic equivalent.

\*Quintile of diet quality index score (a higher quintile indicates better diet quality); <sup>†</sup>Model 1 adjusted for age (year) and total energy intake (kcal/day); <sup>‡</sup>Model 2 adjusted for age (year), total energy intake (kcal/day), income level (< 1; ≥ 1 and < 2; ≥ 2 and < 4; ≥ 4, million Korean won), education level (elementary school graduate or less; middle school; high school; college graduate or more), physical activity (METs), smoking (pack-years), drinking (total alcohol intake, g/day); <sup>§</sup>p for trend < 0.01 by Cox proportional hazards regression analysis.

index, we utilized multiple dietary indexes, MDS, DASH, and RFS, which consist of dietary components known to be related metabolic syndrome [20–22].

Some of study findings support preventive role of better diet quality in occurrence of metabolic syndrome. Specifically, the incidence of metabolic syndrome in the 5th RFS quintile group significantly decreased by approximately 34% compared to the 1st quintile group after adjusting for age and energy intake in women. In men, significant decreasing trend of metabolic syndrome incidence risk was observed across the quintiles of MDS also in an age and energy intake-adjusted model. These results accord with findings from some previous research [23,24]. Kesse-Guyot et al. [23] reported significant inverse relation of adherence to Mediterranean diet with waist circumference, systolic blood pressure, and serum triglycerides in a 6-year prospective study of 3,232 subjects. Incidence of metabolic syndrome also significantly reduced by approximately 50% in the highest tertile of MDS compared to the lowest tertile. From a cohort data analysis of 6,851 participants, a higher adherence to DASH diet was associated with a lower metabolic syndrome development among those with moderate alcohol consumption [24]. These findings suggest that overall healthy diet represented by a priori assessment approach can contribute to metabolic syndrome prevention.

After adjusting for additional factors including income, education, physical activity, smoking, and drinking status, such a significant association between total diet and metabolic syndrome disappeared in the present study similarly to Mirmiran et al.'s [5] study findings. Though we cannot firmly exclude a possibility of no causal relation, it is possible that some methodological constraints affect our study findings. The follow-up period in this study may

have not been long enough to observe the association, and food frequency questionnaire data measured in the baseline examination may have not fully reflected subjects' diet. Additionally, diet indexes employed in this study may have not been optimal to capture multiple dietary factors and complex inter-correlations of dietary factors especially in a context of Korean diet.

The investigation on a role of overall diet in developing metabolic syndrome has been a hot research topic worldwide [25]. This study is meaningful in that it adds evidence from a Korean prospective cohort study to the current global body of academic literature on relation of metabolic syndrome with overall diet. The method of applying the diet quality indexes to Korean dietary data in the present study provides a model of the application approach of the diet indexes for future research.

## CONCLUSION

To our knowledge, this is the first study which prospectively examined the association between total diet quality and metabolic syndrome in Korean adults. The study findings suggest some protective role of better total diet quality in preventing future metabolic syndrome. But no convincing evidence was observed in this study. Future research can explore the study question using other approaches for assessing total diet quality or data with a longer follow-up period.

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