A healthy dietary pattern consisting of a variety of food choices is inversely associated with the development of metabolic syndrome

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Abstract
There are limited data on healthy dietary patterns protective against metabolic syndrome (MetSyn) development. We identified dietary patterns among middle-aged and older adults and investigated the associations with the incidence of MetSyn. A population-based prospective cohort study included 5,251 male and female Koreans aged 40-69 years. At baseline, all individuals were free of MetSyn, other major metabolic diseases, and known cardiovascular disease or cancer. Cases of MetSyn were ascertained over a 6-year of follow-up. Dietary patterns and their factor scores were generated by factor analysis using the data of a food frequency questionnaire. We performed pooled logistic regression analysis to estimate multivariable-adjusted relative risk (RR) and 95% confidence interval (CI) for associations between factor scores and MetSyn risk. Two dietary patterns were identified; (1) a healthy dietary pattern, which included a variety of foods such as fish, seafood, vegetables, seaweed, protein foods, fruits, dairy products, and grains; and (2) an unhealthy dietary pattern, which included a limited number of food items. After controlling for confounding factors, factor scores for the healthy dietary pattern were inversely associated with MetSyn risk (P-value for trend < 0.05) while those for the unhealthy dietary pattern had no association. Individuals in the top quintile of the healthy diet scores showed a multivariable-adjusted RR [95% CI] of 0.76 [0.60-0.97] for MetSyn risk compared with those in the bottom quintile. The beneficial effects were derived from inverse associations with abdominal obesity, low HDL-cholesterol levels, and high fasting glucose levels. Our findings suggest that a variety of healthy food choices is recommended to prevent MetSyn.

Key Words: Dietary pattern, food choices, metabolic syndrome incidence, prospective study

Introduction
Epidemiologic investigations that focus on overall dietary patterns have been widely reported across various chronic diseases [1-3]. Implications from such reports, rather than from findings on specific nutrients associated with a disease, are considered more likely to parallel the situation in real life and thus may be more applicable to public health. There is a paucity of data on the causal association between dietary patterns and the development of metabolic syndrome (MetSyn) [4,5], while data on the association with MetSyn prevalence are accumulating [4,6-11]. Findings among a Spanish population showed that higher dietary scores, which reflect the Mediterranean dietary pattern, are inversely associated with MetSyn incidence during a 6-year follow-up period [12]. A subsequent study focusing on the Mediterranean-style diet among a U.S. population supported the previous findings [13]. The Mediterranean-style dietary pattern was derived from the dietary guidelines for Greek adults and included major food groups such as grains, vegetables, legumes and nuts, fruit, olive oil, dairy products, and fish [4]. There is a prospective study, which explored dietary patterns using data-driven analysis methods rather than using score-based analysis methods for their association with MetSyn [5]. This study examined 2 major dietary patterns, a Western pattern and a prudent pattern, and found that higher factor scores of the Western pattern were positively associated with the risk of MetSyn. However, the prudent pattern including higher consumption of vegetables and fruit, fish and seafood, poultry, whole grains, legumes, low-fat dairy products, and nuts did not reduce the risk of MetSyn [5]. This is possibly because of a limited sample size or the inability to minimize the influence of dietary changes after learning of the diagnosis of dyslipidemia or hypertension. Thus, data on...
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healthy dietary patterns, besides the Mediterranean diet, which are protective against MetSyn incidence, are warranted. In particular, dietary patterns associated with MetSyn incidence have not yet been reported for Asian populations, who tend to have a low fat and high carbohydrate diet or high fish and soybean consumption [10,11,14]. Such diets have been shown to be protective against cardiovascular disease in both Asian and non-Asian populations [15-18].

To test whether specific dietary patterns are associated with MetSyn risk, we prospectively investigated MetSyn incidence, explored dietary patterns, and then analyzed the association between dietary patterns and MetSyn risk among Korean adults. In addition, we examined individual food groups characterizing the dietary patterns in relation to MetSyn risk.

Subjects and Methods

Study population

The present study is embedded within population-based prospective cohort studies, which are ongoing investigations and part of the Korean Genome Epidemiology Study. Detailed information on the cohort studies has been previously reported [19,20]. Cohort members were aged 40-69 years when they were enrolled at one of the 2 study sites, Korea University Ansan Hospital or the Ajou University Medical Center. Baseline examinations at both sites started from June 18, 2001, and they were completed by January 29, 2003. All members were invited to participate in a comprehensive health examination and a questionnaire-based interview. During the site visit, they completed a health examination that included the evaluation of anthropometric parameters, measurement of blood pressure, and the collection of biospecimens for assays. They also completed the questionnaire on demographic information, dietary intake, lifestyle, medical history, and health condition. Participants were invited for biannual follow-up visits in order to have repeated interviews and health examinations. All study procedures were conducted by trained interviewers and health professionals, who followed a standardized protocol. At each visit, participants signed an informed consent form. All study procedures were approved by the Human Subjects Review Committee either at the Korea University Ansan Hospital or at the Ajou University Medical Center.

Since MetSyn incidence was the outcome of interest, participants who were free of MetSyn during the initial examination were eligible for this study (n=7,298). Participants who provided insufficient or inadequate dietary information (for example, reporting >6 standard deviations from the mean of calorie intake) were excluded (n=362). In addition, to minimize the influence of dietary changes after learning of the diagnosis of disease, participants who had self-reported diagnoses of cardiovascular disease, cancer, diabetes mellitus, hypertension, or dyslipidemia were further excluded (n=716). After making these exclusions, 84.4% remained in the study for the 2-year follow-up period from April 17, 2003 to February 20, 2005, and thus, a total of 5,251 participants entered the analysis for this first period. Those who met the same inclusion criteria and were not diagnosed with MetSyn during the first follow-up period remained in the analysis for the second follow-up period from February 21, 2005, to November 17, 2006, and similarly, for the third follow-up period from January 15, 2006 to March 12, 2009. Eighty five percent of the participants in the first period were followed up until the third period.

Dietary assessment

Dietary information was obtained using a semi-quantitative food frequency questionnaire (FFQ), which was developed and evaluated for validity by the Korea Centers for Disease Control and Prevention (Seoul, Korea) [21]. For the recall of food items or beverages consumed in the previous year, participants were asked to complete the FFQ table with inquiries about information on the average consumption frequency and serving size for 103 food items. For each food item, 9 categories of consumption frequency, ranging from “almost never” to “3 or more times per day”, were reported. In addition, the serving size was queried. Trained interviewers showed food pictures to help participants select one of the 3 serving size options (smaller than, equal to, or larger than a standard serving size). The average frequency of each food item was calculated by multiplying the consumption frequency by 0.5 for smaller amounts, 1 for equal amounts, or 1.5 for larger amounts versus the standard serving size. For the purpose of analysis for deriving dietary patterns, the 103 food items from the FFQ were classified into 27 food groups similar to that used in a previous study [22], which investigated dietary patterns among Koreans. The average frequency of consumption for a specific food group was calculated by adding up frequencies for all food items that belonged to that particular food group. The average daily consumption of nutrients was calculated on the basis of FFQ responses and the food composition database published by the Rural Development Administration of Korea [23]. In this study, dietary information from the baseline FFQ, which was collected between June 18, 2001 and January 29, 2003, was utilized for analysis because all of the subjects who responded to the baseline FFQ were ascertained for MetSyn in at least one of the follow-up periods.

Definition and measurements for metabolic syndrome

Individuals were diagnosed with MetSyn if they met at least 3 of the 5 diagnostic criteria for MetSyn. The definition given by Alberti et al. [24] was used for the diagnostic criteria of MetSyn components, except abdominal obesity. An alternative criterion suggested by the Korean Society for the Study of Obesity [25] was used to define abdominal obesity. Thus, the following criteria for each component were used: abdominal...