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Original article

Dyslipidemia patterns are differentially associated with dietary factors

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SUMMARY

Background and aims: Dyslipidemia, a strong predictor of cardiovascular diseases, is prevalent among Korean adults, but little is known about the associations between overall lipid profiles and dietary factors. We identified dyslipidemia patterns among lipid indicators and examined dietary factors associated with dyslipidemia patterns in Korean adults.
Methods: Subjects in this cross-sectional study were recruited from the Family Medicine Division or the Health Examination Center of the general hospital in Seoul between 2010 and 2012. Measurements of biochemical and dietary variables repeated three times were collected from a total of 138 subjects at 3- to 4-month intervals when the subjects visited the hospital. Dietary intake data were obtained using 24-h recalls. In order to estimate typical values for biochemical and dietary variables, the averages of repeated measures for each subject were calculated. To identify dyslipidemia patterns, factor analysis was used based on total cholesterol (TC), low-density lipoprotein cholesterol (LDLC), triglycerides (TG), and high-density lipoprotein cholesterol (HDLC).
Results: Two dyslipidemia patterns, (1) TC & LDLC and (2) TG & HDLC, were identified. Dietary fat and cholesterol intakes were positively associated with the TC & LDLC pattern score, but not associated with the TG & HDLC pattern score. The TG & HDLC pattern was significantly associated with low intakes of calcium, potassium, milk and dairy products.
Conclusions: Two dyslipidemia patterns were associated with dietary factors in Korean adults. Further studies should investigate specific dietary recommendations according to lipid profiles in the prevention and management of dyslipidemia in Korea.

1. Introduction

Dyslipidemia is abnormal lipid metabolism characterized by elevated levels of total cholesterol (TC), triglycerides (TG), and low-density lipoprotein cholesterol (LDLC) and by reduced levels of high-density lipoprotein cholesterol (HDLC) [1]. Dyslipidemia is also a component of metabolic syndrome [2] and a strong predictor of cardiovascular diseases [3,4]. The prevalence of dyslipidemia among Korean adults in 2010 was 59% [5], higher than that in Chinese adults [6]. Among the lipid abnormalities, elevated TG levels and low HDLC levels were the two most prevalent in Korean adults, more prevalent than in U.S. adults [7].

The underlying risk factors suggested for dyslipidemia include age, genetics, diet, smoking, physical activity, and stress [8]. Among these factors, diet has been targeted in the prevention and improvement of dyslipidemia because it is modifiable [1]. Although the effects of diet on dyslipidemia are not fully understood, examination of the dietary factors associated with dyslipidemia is important to prevent chronic diseases, such as cardiovascular diseases and type 2 diabetes [3].

Earlier studies in Western populations focused on the association between dietary fat and cholesterol intake and blood lipids [9–11]. Recent epidemiologic studies in Western countries reported that high consumption of fruits and vegetables was associated with low LDLC levels [12,13], and increased consumption of milk and other dairy products showed protective effects on concentrations of TG and HDLC [14,15].

In contrast to Western diets, Asian diets are rice-based with plenty of plant foods. They are high in carbohydrate and low in fat.

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Several studies in Asian populations reported that low HDLC levels were consistently associated with high carbohydrate intake [16–18], whereas elevated TG levels were related to low consumption of milk and other dairy products [19,20]. In addition, high intake of polyunsaturated fatty acids was inversely associated with TC and LDLC levels [21] but positively associated with HDLC levels [22]. However, only limited data are available on the associations between overall lipid profiles and dietary factors.

As blood lipid variables are highly correlated with each other, factor analysis has been used to identify inter-correlations among biochemical variables and to distinguish patterns among these variables [23]. The aim of this study was to identify dyslipidemia patterns using factor analysis based on four lipid indicators—TC, LDLC, HDLC, and TG—and to examine dietary factors associated with the dyslipidemia patterns in urban Korean adults using repeated measurements of biochemical and dietary variables.

2. Methods

2.1. Study design and subjects

Study subjects were recruited by the Family Medicine Division or the Health Examination Center of Seoul National University Hospital in the Seoul metropolitan area in South Korea. Individuals who were 20 years of age or older and disease free at the time of study enrollment were considered eligible subjects. A total of 277 subjects enrolled in the study between September 2010 and December 2012, of whom 160 revisited the hospital two more times at intervals of three to four months during the study period. For each subject, anthropometric, biochemical, and dietary assessments were conducted three times at each visit, and a questionnaire about sociodemographic and lifestyle information was administered once at study enrollment. Among the 160 eligible subjects, subjects who had incomplete information on anthropometric or biochemical variables ($n = 11$) or who had taken hypolipidemic medications ($n = 11$) were excluded. A total of 138 subjects (45 men and 93 women) were included in the final analyses. The study protocol was approved by the Institutional Review Board at Seoul National University Hospital, and written informed consent was obtained from each subject.

2.2. Assessment of dietary factors

Dietary intake data were collected using 24-h recalls. Three-day dietary intake data were obtained through on-site interviews from all subjects in this study. Following a multiple three-step procedure [24], trained dietitians interviewed the subjects when they visited the hospital regarding their dietary intake over the previous 24-h period. The subject quickly reported food items eaten the previous day in the first step. In the second step, the subject was then questioned in detail about the food reported in the first step. In the third step, the subject was asked about any forgotten food items.

Mean daily intakes of energy and nutrients for each subject were calculated from the three-day dietary intake data using the Diet Evaluation System (Human Nutrition Lab, Seoul National University, Seoul, South Korea), a web-based computer program for dietary assessment [25]. Mean daily alcohol intake was estimated in grams for each subject based on their dietary intake data. We calculated the specific alcohol content of each type of alcoholic beverage according to the Seventh Korean Food Composition Table [26].

Mean daily intakes of six food groups (grains; meat, fish, eggs, and beans; vegetables; fruits; milk and dairy products; and fats, oils, and sugars) were evaluated in servings. The total amount of foods (in grams) that each subject consumed, as indicated by their dietary intake data, was converted to number of servings using a food group database for 4370 common Korean foods [27], which provided numbers of servings per 100 g for each food item for the six food groups. Compliance with the recommended food group intake from the Korean Food Guidance System [28] was calculated as the percentage of recommended servings (consumed number of servings/recommended number of servings $\times$ 100).

2.3. Assessment of biochemical variables and metabolic syndrome

Anthropometric and biochemical variables were measured three times when the subject visited the hospital, and average values of these variables were included in the data analyses. Height and weight were measured using an automatic height and weight scale (BSM330, Biospace, Seoul, South Korea) to the nearest 0.1 cm and 0.1 kg, respectively, in subjects while wearing light clothing and no shoes. BMI was calculated as weight (kg) divided by height squared (m^2). Waist circumference was measured using a tape measure at the narrowest part of the waist over light clothing. Systolic and diastolic blood pressure was measured using an automatic sphygmomanometer (EASY X 800 R/L, Jawon Medical, Kungsan, South Korea) after subjects had rested for 10 min in the sitting position.

Blood samples were collected after fasting for at least 8 h for each subject and were analyzed using an automatic analyzer (200 FR, Toshiba, Tokyo, Japan) in the clinical laboratory of Seoul National University Hospital. Blood glucose was measured using the oxidase method; TG, TC, and LDLC were measured using enzymatic methods; and HDLC was measured using the elimination method.

Metabolic syndrome was defined based on the National Cholesterol Education Program Adult Treatment Panel III Criteria [2] with a modified waist circumference cutoff for Korean adults [29]. It was diagnosed if three or more of the following components were present: 1) elevated waist circumference ($\geq$90 cm in men and $\geq$85 cm in women), 2) elevated TG ($\geq$150 mg/dL), 3) reduced HDLC ($<$40 mg/dL in men and $<$50 mg/dL in women), 4) elevated fasting blood glucose ($\geq$100 mg/dL) or diagnosis of diabetes, and 5) elevated blood pressure (systolic blood pressure $\geq$ 130 mmHg or diastolic blood pressure $\geq$ 85 mmHg) or diagnosis of hypertension. All subjects were questioned by a physician about diagnosis and treatment of diabetes and hypertension at the beginning of the study.

2.4. Assessment of sociodemographic and lifestyle variables

Information on sociodemographic (e.g., sex, age, and education) and lifestyle (e.g., history of disease, medication use, smoking status, alcohol use, and physical activity) variables was collected through a combination of self-administered and interviewer-administered questionnaires. Education was categorized as elementary school, secondary school, and college or more. Smoking status and alcohol use were classified into three categories: current-, ex-, and non-. Physical activity was assessed based on how many days per week subjects had exercised for 30 min or more over the previous six months.

2.5. Statistical analyses

All statistical analyses were conducted using SAS software, version 9.3 (SAS Institute, Cary, NC, USA). Factor analysis with varimax rotation was used to identify dyslipidemia patterns based on TC, LDLC, TG, and HDLC. TG and HDLC were included in factor analysis after log transformation because these variables showed skewed distributions. The eigenvalue, scree test, and interpretability were considered to determine the patterns to retain [30].