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Original article

Very-low-fat diets may be associated with increased risk of metabolic syndrome in the adult population

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SUMMARY

Background & aims: Although fat intake has often been targeted to decrease the prevalence of metabolic syndrome; however decreasing dietary fat intake has not had this result. We studied the association between fat intake and the prevalence of metabolic syndrome in adults using KNHANES 2007–2013 data, a representative sample of the non-institutionalized civilian population.

Methods: This cross-sectional study included 34,003 Korean adults aged ≥19 years. Adjusted odds ratios (OR) for the components of metabolic syndrome were measured according to fat intake (≤15, 15–25, ≥25% of daily energy intake) while controlling for covariates that affect metabolic syndrome using linear and logistic regression analysis while incorporating the sample weights for the complex sample design of the survey.

Results: Surprisingly, the prevalence of metabolic syndrome was significantly higher in the ≤15% fat intake group (OR = 1.277), accompanied by lower daily energy intake compared to the reference group (≥25% fat intake). Higher daily fat intake was associated with significantly lower ORs for four components of metabolic syndrome, except diabetes mellitus, using continuous variable analysis, whereas only three serum components (serum HDL, serum triglyceride, and blood pressure) exhibited significantly higher ORs in the lowest tertile of dietary fat intake (≤15%) compared with the reference group (≥25% fat-intake tertile). Subjects in a low-fat intake group had about 5.4 g polyunsaturated fatty acid/day that did not meet the recommended intake. Consumption of grain groups was a significant predictor of low fat intake, whereas milk food groups were significant predictors of not having low fat intake. Subjects in the low-fat group (≤15%) had much lower daily energy intake, by 500 kcal, compared with subjects who consumed high-fat diets (≥25%). All nutrients except carbohydrates had significantly lower mean values in the low-fat-intake group as compared to the high-fat-intake group.

Conclusions: Low fat intake, <15%, was associated with a higher incidence of metabolic syndrome in the adult population, despite the daily energy intakes being lower by 500 kcal; this may be related to lower intake of various nutrients other than carbohydrates.

1. Introduction

Metabolic syndrome is defined by the presence of related cardiovascular disease risk factors including: insulin resistance, abdominal obesity, dyslipidemia, hypertension, and a pro-inflammatory state [1]. Metabolic syndrome has been linked to the development of type 2 diabetes mellitus, atherosclerosis, some cancers, and a profoundly increased risk of morbidity and mortality [2]. Lifestyle interventions remain the primary mode of therapy for metabolic syndrome. Some risk factors, including high-fat diet, inactivity and estrogen deficiency, are well characterized [3]. Dietary patterns are important modifiable factors that may be useful for preventing the development of metabolic syndrome. However, the relationship between the metabolic syndrome and dietary patterns has not been fully elucidated, although a high-fat diet,

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which leads to obesity and dyslipidemia, is a widely accepted risk factor for metabolic syndrome [4,5].

The traditional Asian diet is characterized as high in carbohydrates, with an abundance of vegetables, and has been considered beneficial for preventing metabolic syndrome in the Asian population [5,6]. However, the Westernization of lifestyle and dietary patterns may result in increased prevalence of metabolic syndrome in Asian countries. Fat consumption rose remarkably, from 7.2% to 19.0% of total energy consumption, between 1969 and 1998 in Korea [7,8]. Although during that time period the prevalence of metabolic syndrome had not been measured in the population, this increase is believed have contributed to the incidence of metabolic syndrome components. Fat intake has not markedly increased in KNHANES data since 1998, remaining at about 17–19% of total energy intake, although some parts of population have markedly increased their fat intake [7,8]. Interestingly, the incidence of metabolic syndrome increased markedly in Korea, by 6.5%, between 1998 and 2007, whereas from 2008 to 2012 it increased slowly, by 1.1% [7–9]. These results have suggested that an increase in fat intake to an average of ~20% may not promote metabolic syndrome. Previous studies have demonstrated that high carbohydrate intake (>60% of energy) increases the risk of metabolic syndrome in middle-aged Korean type 2 diabetic women [3], and high-carbohydrate diets (>57.4% of energy in men and >59.1% of energy in women) are associated with a low serum HDL–cholesterol concentration in US men and high serum triglyceride in US women [10]. However, pregnant Korean women have higher fat intake (about 28% of energy intake) during pregnancy, and women with higher fat intake are more likely to develop gestational diabetes [11,12]. Thus, the role of dietary fat consumption in the development of metabolic syndrome in Koreans is not clear.

Furthermore, US NHANES data indicate that the prevalence of metabolic syndrome components including obesity, high blood pressure, dyslipidemia, and diabetes increased from 1982 to 2006 in adults [13,14]. However, the intake of energy, saturated fat, polyunsaturated fat, and cholesterol did not change markedly between 1988 and 2008 in US adults aged 20–74 years; indeed, it was higher during 1971–1980 than during 1988–2008 [15]. On the other hand, the prevalences of obesity and insulin resistance increased substantially over 17 years in association with increases in the percent of total fat and protein in the diets of adults aged ≥25 years in the Framingham Heart Study Offspring Cohort (1991–2008) [16]. Furthermore, there are ethnic differences in macronutrient intake, and these may exert different influences on the development in metabolic syndrome [17]. Thus, the amount of fat and carbohydrate intake that is beneficial for reducing metabolic syndrome remains unclear.

However, in nutritional education, high fat intake is considered the major cause of metabolic diseases because it is associated with a higher incidence of metabolic syndrome in Western countries [18]. Some people in Korea try to consume food that is lower in fat, but they may not have consumed as much fat as they need. The Korean dietary reference intake (KDRI) recommends fat consumption of around 25% of energy intake [19]. Some people consume too little fat, far below the KDRI recommendation, which results in diets high in carbohydrates and low in proteins [7,8]. Asians, including Koreans, have historically consumed high-carbohydrate, low-fat diets. Researchers have considered that this dietary pattern may not be beneficial in reducing the risk of metabolic syndrome. Therefore, we hypothesized that different fat intakes modified the components of metabolic syndrome in Korean adults. We studied the association between fat intake and the prevalence of metabolic syndrome in adults ≥19 years of age using the KNHANES 2007–2013 data, a representative sample of the non-institutionalized civilian population.

2. Methods

2.1. Design and data collection

This study utilized data obtained from the Korea National Health and Nutrition Examination Survey (KNHANES) 2007–2013, which includes KNHANES IV (2007–2009), KNHANES V (2010–2012) and KNHANES VI (2013) surveys. KNHANES surveys are conducted annually using a rolling sampling design that involves a complex, stratified, multistage probability-cluster survey of a representative sample of the non-institutionalized civilian population in South Korea. The KNHANES is a large representative population study with rigorous quality controls. The survey is performed by the Korean Centers for Disease Control and Prevention and the Korean Ministry of Health and Welfare. It has three components: a health interview, a health examination, and a nutrition survey. The survey was approved by the Institutional Review Board of the Korean Centers for Disease Control and Prevention (approval nos. 2008-04EXP-01-C, 2009-01CON-03-2C, 2010-02CON-21-C and 2013-07CON-03-4C).

The present cross-sectional analysis was restricted to adults ≥19 years of age who completed the health examination survey and the nutrition survey (n = 34,003). Detailed descriptions of the design of the survey have been reported previously [20]. Briefly, the participants ages, education, smoking histories and alcohol intakes were obtained during the health interview. Height and weight measurements were performed, with the participants wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in meters (kg/m^2). Obesity was categorized into three groups according to the Asian obesity definition by recommended by International Obesity Task Force and the World Health Organization (WHO) Regional Office for the Western Pacific Region [21,22]: lean (BMI < 18.5), normal (18.5 ≤ BMI < 25), and obese (BMI ≥ 25). Age reported at the time of the health interview was categorized into five groups. Area of residence was categorized into urban (administrative divisions of a city) and rural areas (not classified as administrative divisions of a city). Income level was categorized into four quartile groups (1st Q–4th Q). Education level was categorized into three groups: below high school, high school, and college or higher. Occupation was categorized into four groups: clerical, manual, technical, and unemployed.

Smoking status was divided into three categories: current smoker, past smoker and never-smoker. Smoking status was defined based on self-reported cigarette use: never-smokers had smoked less than 100 cigarettes in their lifetime; participants who had smoked 100 or more cigarettes were considered past or current smokers, based on current tobacco use. Alcohol consumption was assessed by asking the participants about their drinking behavior during the month prior to the interview, including their average frequency (days per month) of alcoholic beverage consumption and amount (in mL) of alcoholic beverages ingested on a single occasion. The responses were converted into the amount of pure alcohol (in grams) consumed per day. Alcohol consumption status was categorized into four groups according to average daily alcohol consumption: nondrinkers, and light (1–15 g), moderate (16–30 g), and heavy (>30 g) drinkers.

Regular exercise was defined as regular exercising ≥30 min at a time at least five times per week, as moderate exercise activities (swimming slowly, playing doubles tennis or volleyball, and participating in occupational or recreational activities while carrying light objects), or for ≥20 min at a time at least three times per week in vigorous exercise activities (running, climbing, cycling fast, swimming fast, playing football, basketball, squash or

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