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Nutrition 25 (2009) 526–531

NUTRITION

www.nutritionjrnl.com

Applied nutritional investigation

Combined effects of saturated fat and cholesterol intakes on serum lipids: Tehran Lipid and Glucose Study

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Manuscript received August 4, 2008; accepted November 8, 2008.

Abstract

Objective: This study investigated the combined effect of saturated fat and cholesterol intake on serum lipids among Tehranian adults.

Methods: In 443 subjects ≥18 y, dietary intake was assessed. Height and weight were measured and body mass index was calculated. Serum cholesterol, triacylglycerol, high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol levels were calculated. Cholesterol intakes ≥300 mg/d and saturated fat intakes ≥7% of total energy were defined as high intakes. Individuals were categorized into four groups based on cholesterol and saturated fat intakes.

Results: Subjects' mean age was 40.1 ± 14.6 y; those in whom cholesterol and saturated fat intake was normal had significantly less energy and fat intake than those with high cholesterol and saturated fat intakes ($P < 0.01$). Saturated fat intake had a significant effect on serum total and HDL-C levels. Subjects with a normal saturated fat intake had significantly less serum total and HDL-C than those who had high saturated fat intake ($P < 0.01$ and $P < 0.05$, respectively). Adjusting for age, sex, and body mass index, the main effect of cholesterol intake on HDL-C was significant ($P = 0.05$). Mean serum HDL-C was lower in subjects who had normal cholesterol intake than in those with high cholesterol intake.

Conclusion: These results show that cholesterol and saturated fat intakes have no combined effect on serum low-density lipoprotein cholesterol level, whereas cholesterol intake per se affects serum HDL-C level.

Keywords: Saturated fat; Cholesterol; Combined effect; Serum lipids; Tehran

Introduction

Although significant reductions have occurred in the incidence of cardiovascular disease since the mid 1970s, it remains the primary cause of morbidity and mortality in many countries [1]. Risk factors of cardiovascular disease include smoking, hypercholesterolemia, hypertension, diabetes mellitus, physical inactivity, decreased high-density lipoprotein (HDL), abdominal obesity, high triacylglycerols, excessive alcohol consumption, aging, and dietary patterns [2–4]. As early as at the beginning of the previous century, animal studies pointed to a causal role of dietary cholesterol in atherogenesis. In humans, however, most observational studies have not provided convincing evidence for an impact of cholesterol intake on coronary heart disease (CHD) [5]. The eating pattern associated with CHD is characterized by a high intake of total fat, saturated fatty acids (SFAs), and cholesterol and a low intake of fiber and polyunsaturated fatty acids. In typical Western diets, the amounts of total fat, SFA, and cholesterol are strongly correlated with each other, whereas they have negative associations with the intake of fiber and polyunsaturated fatty acids. Thus, it has not been possible to determine whether the association between the above-mentioned eating pattern and CHD is due to the high consumption of SFAs and/or cholesterol or an insufficient supply of at least one protective factor such as fiber or polyunsaturated fatty acids [5]. Some experimental and pathologic studies have shown a strong association between hypercholesterolemia and the likelihood of developing atherosclerotic CHD. The

This study was funded by the Research Institute of Endocrine Sciences, Shaheed Beheshti University of Medical Sciences, Tehran, Iran.

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0899-9007/09/$ – see front matter © 2009 Published by Elsevier Inc.
doi:10.1016/j.nut.2008.11.018

effects of diet on serum low-density lipoprotein cholesterol (LDL-C) have consistently been documented and high intakes of SFAs, *trans*-unsaturated fatty acids, cholesterol, and excess calorie intake are known to lead to obesity [6–8]. Some studies have shown that dietary cholesterol has a lesser regulatory effect on plasma cholesterol compared with SFAs; based on these studies, diets low in cholesterol and high in saturated fat increase LDL-C, whereas consumption of egg yolk and oyster, which have a very high cholesterol content without excess saturated fats, results in only a minimal increase in LDL-C [5–10]. Some experimental studies have shown that there are synergistic interactions of SFA and cholesterol in the regulation of serum cholesterol level [9]. In addition, differences in genetic constitution (apolipoprotein [apo] E and apoA-IV) may affect cholesterol metabolism and responses to diet [9]. Despite numerous studies done about the effect of SFA and cholesterol intake on serum lipids, there are limited data available on plasma lipid responses to the combined effect of dietary fat and cholesterol. This study was therefore conducted to investigate the combined effect of saturated fat and cholesterol intake on serum lipids among Tehranian adults.

Materials and methods

This population-based cross-sectional study was a part of a dietary intake assessment that was conducted within the framework of the Tehran Lipid and Glucose Study (TLGS), a prospective study of a representative sample of residents of District 13 of Tehran, that aimed at ascertaining the prevalence of non-communicable disease risk factors and developing a healthy lifestyle to curtail these risk factors [11,12].

Subjects

In the TLGS, 15 005 persons ≥3 y of age were selected by a multistage cluster, random sampling method. A representative sample of 1474 persons was randomly selected for dietary assessment; of these, 443 (171 men and 272 women) ≥18 y of age who had all the relevant data and had not used any hypoglycemic agents and lipid-lowering and antihypertensive prescription medications participated in this study. Written informed consent was obtained from each subject and the protocol of this study was approved by the research council of the Research Institute of Endocrine Sciences of Shaheed Beheshti University of Medical Sciences.

Assessment of dietary intake

Subjects were interviewed privately, face to face; trained interviewers using pretested questionnaires conducted the interviews. All questionnaires used in the study were validated previously in the Nationwide Household Food Consumption Survey Project, which has been reported in Persian [13]. Dietary intake assessment was undertaken with 2-d 24-h recalls by expert interviewers. These 2 d were selected randomly from the weekdays. Because the weekend diet does not reflect the usual diet, we did not select the weekend. The first recall was performed at the subject's home and the second at a clinic visit in the diet unit of TLGS. These 2 d were among usual days for subjects. Standard reference tables were used to convert household portions to grams for computerization [14]. After coding of diaries, the dietary recall form was linked to a nutrient database (Nutritionist III designed for Iranian foods) and daily energy and nutrient intakes (carbohydrates, proteins, and fats) for each individual were determined from the means of the two 24-h dietary recalls.

Assessment of other variables

All information regarding age, sex, education, marital status, and job was obtained using validated questionnaires. Weight was measured while the subjects were minimally clothed without shoes using digital scales and recorded to the nearest 100 g. Height was measured in a standing position, without shoes, using a tape meter, while the shoulders were in a normal position [15]. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. A blood sample was drawn from all subjects between 07:00 and 09:00 h into Vacutainer tubes after 12- to 14-h overnight fasting [16]; the samples were centrifuged within 30–45 min of collection. All blood lipid analyses were done at the TLGS research laboratory on the day of blood collection. The analysis of samples was performed using a Selectra 2 autoanalyzer (Vital Scientific, Spankeren, The Netherlands). Serum total cholesterol and triacylglycerol concentrations were measured by commercially available enzymatic reagents (Pars Azmoon, Tehran, Iran), adapted to the Selectra autoanalyzer. HDL cholesterol (HDL-C) was measured after precipitation of the apoB-containing lipoproteins with phosphotungstic acid. LDL-C was calculated according to the method of Friedewald et al. [17]; it was not calculated when the serum concentration of triacylglycerol was >400 mg/dL. All samples were analyzed when the internal quality control met the acceptable criteria. Inter- and intra-assay coefficients of variation were 2% and 0.5% for total cholesterol and 1.6% and 0.6% for triacylglycerol, respectively.

Definition of terms

Intakes of cholesterol ≥300 mg/d were defined as high and those <300 mg/d as normal. For SFA an intake ≥7% of total daily energy intake was defined as high and an intake <7% as normal [18].