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# Diacylglycerol oil ingestion in type 2 diabetic patients with hypertriglyceridemia

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**Abstract**

**Objective:** Coronary arteriosclerotic heart disease frequently develops in patients with diabetes. Decreased serum high-density lipoprotein cholesterol concentration and low-density lipoprotein (LDL) particle size, accompanied by hypertriglyceridemia, are associated with the onset of atherosclerosis. We recently reported that hypertriglyceridemia was significantly improved in patients with type 2 diabetes who ingested diacylglycerol (DAG) oil. The effect on variables, including LDL particle size related to lipid metabolism, however, was not examined. The present study investigated the effects on these variables in more detail.

**Methods:** Patients with type 2 diabetes ($n = 24$) were assigned to receive DAG oil or triacylglycerol oil, and a 3-mo, single-blind, controlled study was performed. Patients replaced cooking oil in their daily diet with DAG or triacylglycerol oil, and anthropometry and blood sampling were performed at monthly intervals.

**Results:** There were no significant differences in calorie intake or amount of test oil ingested between groups. Waist circumference and serum triacylglycerol concentrations were significantly lower and serum concentrations of high-density lipoprotein cholesterol and apolipoprotein-AI were significantly higher in the DAG oil group than in the triacylglycerol oil group. Plasma plasminogen activator inhibitor-1 concentrations were significantly lower in the DAG oil group. LDL particle size tended to increase in the DAG oil group and was significantly larger in patients who had a small initial LDL particle size (<25.5 nm). There were no significant differences in variables related to glucose metabolism or in serum concentration of free fatty acids or total ketone bodies.

**Conclusions:** These results indicate that DAG oil may be useful for patients who have type 2 diabetes in the management of obesity and lipid abnormalities. 

*Keywords:* Diacylglycerol; Humans; Diabetes; Hypertriglyceridemia; Low-density lipoprotein particle size

## Introduction

Coronary arteriosclerotic heart disease (CHD) frequently develops in patients who have diabetes [1]. Decreased serum high density and decreases in serum high-density lipoprotein cholesterol (HDL-C) concentration and low-density lipoprotein (LDL) particle size, accompanied by hypertriglyceridemia and postprandial hyperlipidemia, are associated with the onset of arteriosclerosis [2–4]. Several large-scale epidemiologic studies have suggested that a remission in hypertriglyceridemia prevents CHD [5,6]; there-

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Table 1
Characteristics of subjects*

| | TAG group | DAG group |
|---|---|---|
| No. of subjects | 13 | 11 |
| Male/Female | 7/6 | 4/7 |
| Age (y) | 54.3 ± 13.1 | 61.5 ± 6.2 |
| Height (cm) | 163.5 ± 10.8 | 154.5 ± 8.1 |
| Weight (kg) | 75.7 ± 21.2 | 65.2 ± 8.9 |
| BMI (kg/m$^2$) | 28.0 ± 5.9 | 27.3 ± 3.4 |
| Medication | | |
| Non-drug | 5 | 3 |
| Statin | 1 | 0 |
| EPA | 1 | 0 |
| SU | 3 | 6 |
| Insulin preparation | 3 | 2 |

BMI, body mass index; DAG, diacylglycerol; EPA, eicosapentaenoic acid; SU, sulfonylurea drug; TAG, triacylglycerol (Nissin Oil Mills, Tokyo, Japan)

* Values are means ± standard deviations.

fore, an improvement in hypertriglyceridemia might be particularly important for patients who have diabetes.

Small, dense LDL particles are more atherogenic than larger, less dense particles [4]. Recent evidence reported in the Quebec Cardiovascular Study, in which there was a 5-y follow-up, has suggested that an increased proportion of small LDL particles (<25.5 nm) is closely associated with future cardiovascular disease, even in the presence of relatively normal LDL-C concentration, and that LDL particle size might be a factor that can be used to accurately predict risk of ischemic heart disease [7].

A diet low in fat, low in glucose, and high in food fiber is recommended for diabetics. Clear-cut efficacy is not readily achieved by dietary therapy alone in clinical practice. We previously reported the efficacy of diacylglycerol (DAG) oil in patients who had diabetes and hypertriglyceridemia in a parallel group study [8] in which hypertriglyceridemia was significantly improved in patients who ingested DAG oil daily as a cooking oil compared with patients who used conventional cooking oil.

In the present study, we examined the influence of long-term ingestion of DAG oil on variables including LDL particle size related to lipid metabolism in more detail in patients with type 2 diabetes.

## Materials and methods

### *Subjects and study design*

The randomized, single-blind, controlled parallel trial was conducted at the Itami City Hospital, Itami, Japan. Potential subjects were screened during visits to the clinic. This study with human volunteers was performed in accordance with the Helsinki Declaration of 1975 as revised in 1983. The procedures were fully explained to the volunteers. All subjects gave their signed informed consent before the start of the study.

The subjects included 24 outpatients ages 38 to 79 y under continuous nutritional counseling (dietary therapy) for diabetes (Table 1). These patients were assigned to one of two groups: a DAG oil group comprised of 11 patients (mean age 61.5 ± 6.2 y, four men and seven women) and a triacylglycerol (TAG) oil group of 13 patients (mean age 54.3 ± 13.1 y, seven men and six women). The DAG and TAG oil groups replaced their usual cooking oil with DAG oil and TAG oil, with the same fatty acid composition as the DAG oil, respectively, and ingested the oil with a target intake of 10 g/d. The study period was 3 mo after initiating the use of the test oil in both groups. Patient medication is reported in Table 1.

### *Test oils*

The test DAG oil was prepared from rapeseed and soy oils in the presence of an immobilized lipase, according to the method reported by Huge-Jensen et al. [9], and TAG oil with the same fatty acid composition as DAG oil was prepared by mixing rapeseed oil, soybean oil, and safflower oil. The fatty acid compositions of the DAG and TAG oils are listed in Table 2. DAG oil comprised 84.4 g/100 g of DAG, 14.1 g/100 g of TAG, and 1.2 g/100 g of monoacylglycerol (MAG). The ratio of 1,3-DAG to 1,2-DAG (2,3-DAG) was 7:3.

### *Dietary record*

Subjects were instructed to record their daily meals and snacks in a dietary diary for 3 consecutive days at the beginning and end of the test period. At the time of each clinic visit, a dietitian reviewed the food diaries and meal record after clarifying the results by patient interviews. Mean daily intakes of energy, fat, and cooking oil were calculated from the dietary record by a dietitian on the basis of the 5th Revision of the Standard Tables of Food Composition in Japan. DAG intake was estimated from the amount of DAG oil ingested and the DAG content of the DAG oil (80 g/100 g).

Table 2
Fatty acid and acylglycerol compositions of test oils (wt%)

| | TAG oil | DAG oil |
|---|---|---|
| Fatty acid | | |
| C16:0 | 5.7 | 3.1 |
| C18:0 | 2.1 | 1.3 |
| C18:1 | 35.8 | 37.4 |
| C18:2 | 46.4 | 48.2 |
| C18:3 | 8.1 | 7.0 |
| Acylglycerol | | |
| TAG | 90.7 | 14.1 |
| DAG | 4.8 | 84.4 |
| Monoacylglycerol | 0.0 | 1.2 |
| Free fatty acid | ND | ND |

DAG, diacylglycerol; ND, not determined; TAG, triacylglycerol