Effect of Moderate to Very Low Fat Defined Formula Diets on Serum Lipids in Healthy Subjects

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ABSTRACT

Serum total cholesterol, high density lipoprotein (HDL) cholesterol, and triglyceride levels were studied in healthy male and female subjects consuming for one-week periods a diet of conventional food (CF) providing 42% of energy as fat, principally butter fat, and then in random order nutritionally complete, defined formula diets of moderate (32%) to very low (1%) fat content. Compared to CF, the formula with 32% of energy as corn oil lowered serum cholesterol by 25% and the ratio of total to HDL-cholesterol by 13%. Low (9%) and very low (1-3%) fat formulas reduced HDL-cholesterol by as much as 40%, raised the total:HDL-cholesterol ratio by about 20% and raised serum triglyceride levels by as much as 100%. When low and very low fat formulas were ingested for three weeks, these effects persisted although maximal responses occurred during the first week. These results demonstrated that a moderate fat formula diet with a high P/S ratio had a more favorable effect on serum lipid levels than various low fat formulas. Low fat conventional food diets should be studied in long-term controlled metabolic experiments before such diets are recommended to the general population for coronary heart disease or cancer prevention.

INTRODUCTION

The positive association of low density lipoprotein (LDL) cholesterol with coronary heart disease (CHD) and the inverse relationship of high density lipoprotein (HDL) cholesterol with CHD are well known (1-3). Although elevated serum triglycerides are common in patients with CHD, some researchers have proposed that the relationship is not causal (4-7). High serum triglycerides are associated with other known risk factors, namely reduced HDL-cholesterol concentrations (5).

Dietary modulation of serum lipids is controversial and has attracted considerable research interest for several decades. There is evidence that reduced and modified fat intakes (to 30% of calories, P/S ratio > 1) lower serum total cholesterol levels by 10% or about 20 mg/dl serum (8). In normal humans the intake of large amounts of dietary cholesterol does not produce direct effects on plasma cholesterol because of regulation mediated by lipoprotein receptors (9). Carbohydrate-induced hypertriglyceridemia is well recognized, especially in subjects whose triglyceride levels already are elevated (10,11). Complex carbohydrates have a more transitory effect than simple ones on serum triglycerides (12). The effects of dietary treatment on serum HDL-cholesterol concentrations are less clear, and more information is needed (13). In short term feeding studies, high carbohydrate, low fat diets reduced serum HDL-cholesterol levels (14). Reports on the influence of changes in dietary polyunsaturated fat and cholesterol vary (13). The object of the experiments reported herein was to compare the effect of conventional foods simulating the usual American diet and of seven commercial defined formula diets (DFDs) of varying fat and carbohydrate content on lipid levels of healthy young adults.

METHODS

General Design

The effect of DFDs on serum lipid parameters was investigated in three experiments, consisting of four or five dietary periods each seven days in length. Conventional foods (Table 1) were consumed during the initial period of all experiments and during the final period of Experiment 2. The DFDs, three per experiment (Table 1), were consumed in randomized order. Body weights were monitored daily throughout the study. Calorie intakes were adjusted to maintain subjects' initial body weight by altering intakes of cornstarch pudding (conventional food periods) or liquid formula. All diets were nutritionally complete. Subjects were allowed caffeine-free, sugar-free beverages and gum ad libitum.

Fasting blood samples were drawn by venipuncture on the first day of each experiment and on the morning following the comple-
LOW FAT DIETS AND SERUM LIPIDS

TABLE 1
Composition of Experimental Diets

<table>
<thead>
<tr>
<th>Diet</th>
<th>Fat</th>
<th>Carbohydrate</th>
<th>Protein</th>
<th>Cholesterol (mg)</th>
<th>P/S ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional foods (CF) a</td>
<td>42</td>
<td>44</td>
<td>14</td>
<td>305</td>
<td>0.1</td>
</tr>
<tr>
<td>Moderate fat DFD (MF1) (corn oil) (corn solids) (casein, soy)</td>
<td>32</td>
<td>53</td>
<td>15</td>
<td>0</td>
<td>4.1</td>
</tr>
<tr>
<td>Moderate fat DFD (MF2) (MCT, corn oil, corn solids) (casein, soy)</td>
<td>32</td>
<td>55</td>
<td>14</td>
<td>0</td>
<td>0.67</td>
</tr>
<tr>
<td>Low fat DFD (LF1) (safflower oil, MCT, glucose, oligo- and polysaccharides, sucrose) (soy, whey and meat hydrolysate; EAA) d, e</td>
<td>9</td>
<td>74</td>
<td>17</td>
<td>0</td>
<td>0.86</td>
</tr>
<tr>
<td>Low fat DFD (LF2) (safflower oil, MCT, glucose, oligo- and polysaccharides, sucrose) (soy, whey and meat hydrolysate; EAA) d, e</td>
<td>9</td>
<td>74</td>
<td>17</td>
<td>0</td>
<td>0.86</td>
</tr>
<tr>
<td>Low fat DFD (LF3) (safflower oil, MCT, glucose, oligo- and polysaccharides, sucrose) (egg albumin and soy hydrolysate)</td>
<td>9</td>
<td>74</td>
<td>17</td>
<td>0</td>
<td>0.86</td>
</tr>
<tr>
<td>Very low fat DFD (VLF1) (safflower oil, maltodextrin, modified cornstarch) (casein hydrolysate, AA)</td>
<td>3</td>
<td>83</td>
<td>14</td>
<td>0</td>
<td>5.5</td>
</tr>
<tr>
<td>Very low fat DFD (VLF2) (safflower oil, glucose oligo-saccharides) (AA)</td>
<td>1</td>
<td>82</td>
<td>18</td>
<td>0</td>
<td>5.5</td>
</tr>
</tbody>
</table>

aBasal CF female diet (grams/day): orange juice, 100; banana, 75; bread, 80; cornflakes, 15; jelly, 15; skim milk, 600; butter, 52; apricots, 100; pineapple, 50; lettuce, 30; cheese, 45; ice cream, 100; broccoli, 100; ground beef, 100; potatoes, 100; carrots, 40; peaches, 40; cornstarch pudding, sufficient to maintain body weight. Male portions were 38% larger.
bDFD = defined formula diet.
cMCT = medium-chain triglycerides.
dEAA = essential amino acids.
eLF1 and LF2 differed with regard to commercial source of meat hydrolysate.

The specific study design consisted of each dietary period. In Experiments 1 and 3 an adjustment day followed each dietary period. On the morning of the adjustment day subjects consumed a test meal of the moderate fat formula containing corn oil (MF1). Blood was sampled at intervals after feeding. Serum lipid levels during absorption of the fat load were monitored to assess the effect of the previous week's dietary adaptation. The subjects consumed the next period's diet for the remainder of the adjustment day.

Specific Study Design

Experiment 1. Experimental diets were the two moderate fat formulas, and a low fat formula, LF1 (Table 1). An adjustment day between dietary periods was included during which subjects received test meals providing 22 to 40 g of corn oil, depending on their usual calorie intake. Blood was sampled one and two hr after the meal.

Experiment 2. Experimental diets were LF1 and the very low fat formulas, VLF1 and VLF2. There was no adjustment day. Subjects consumed conventional foods during a five-day terminal period.

Experiment 3. Experimental diets were low fat formulas LF1, LF2 and LF3. On the last morning of each experimental dietary period (Day 7) all subjects consumed 600 ml (6 g fat) of their usual low fat formula for the period. The study included an adjustment day (Day 8) on which all subjects received a test meal of MF1 plus extra corn oil to provide a total of 50 g corn oil. On both Days 7 and 8, serum triglyceride levels were evaluated before and two hr after the test meal.