

# High-oil compared with low-fat, high-carbohydrate diets in the prevention of ischemic heart disease<sup>1,2</sup>

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**ABSTRACT** Reducing the intake of saturated fatty acids reduces the risk of coronary disease. This paper reviews the merits of two types of diets reduced in saturated fat. Low-fat, high-carbohydrate diets lower plasma low-density lipoprotein (LDL) but also lower high-density lipoprotein (HDL) concentrations and raise plasma very-low-density lipoprotein. The predicted net effect on coronary risk is zero. Weight loss with low-fat diets is modest and insufficient to offset the fall in HDL. Evidence for other beneficial effects of low-fat diets is incomplete. In contrast, diets low in saturated fat but high in unsaturated oils improve the ratio of HDL to LDL in plasma and thus reduce the predicted coronary risk. Recommendations to reduce total fat intake are therefore too imprecise; guidelines should aim specifically at saturated and probably also at *trans* fatty acids, whereas recommendations for restriction of *cis*-unsaturated fatty acids are not supported by firm scientific evidence. *Am J Clin Nutr* 1997;66(suppl):974S–9S.

**KEY WORDS** Saturated fat; unsaturated fat; LDL; HDL; VLDL; atherosclerosis; coronary disease; low-fat, high-carbohydrate diet

## INTRODUCTION

There is widespread agreement that consumption of foods high in saturated fatty acids and cholesterol promotes the risk of ischemic heart disease and expert committees worldwide have recommended that the intake of such fats be reduced. There is less agreement as to which foods should take their place. The two major contenders are foods high in starch and fiber (complex carbohydrates) and oils high in unsaturated fatty acids.

Recommendations made in the 1960s were based largely on the effect of diet on the total cholesterol concentration in plasma. Replacement of saturated fats by carbohydrates and by monounsaturated fatty acids, ie, oleic acid, lowers total cholesterol to about the same extent, whereas (n-6) polyunsaturated fatty acids, chiefly linoleic acid, cause some additional lowering in total cholesterol (1–3). Diets high in carbohydrate or monounsaturated fat were therefore considered less effective than diets high in linoleic acid-rich oils such as soybean, corn, or sunflower oil. Also, the only fat high in oleic acid available at the time was olive oil, which in Northern Europe and North America was considered exotic and expensive.

The effectiveness of oils high in polyunsaturated fatty acids, such as soybean and corn oil, in the prevention of ischemic heart disease was also shown in controlled trials with clinical

endpoints (4–7) [for a review *see* (8)]. As a result, early recommendations stressed diets with a high ratio of polyunsaturated to saturated fatty acids (high P:S). In the course of time, however, worries arose over possible adverse effects of high polyunsaturated fat intakes. Initially, these focused on cancer risk and later also on the oxidizability of polyunsaturated fatty acids. Such considerations helped to shift the emphasis of dietary recommendations from diets high in polyunsaturated fat to diets low in fat and high in carbohydrate. Interest in monounsaturated fat has also increased (9, 10) and has received additional stimulation from the availability of modern rapeseed oil as a cheap and plentiful source of oleic acid (11).

Here I review the merits of various types of diet low in saturated fat and cholesterol. In view of the adverse effects of *trans* fatty acids on serum lipoproteins (12), I include *trans* fatty acids with the saturated fatty acids.

## POTENTIAL REPLACERS OF SATURATED AND *trans* FATTY ACIDS

People who are obese are recommended to reduce their intake of saturated fats, both to lower serum cholesterol and to reduce energy intake, and are therefore encouraged to not make up the energy left out. However, those who are not obese will need alternative sources of energy when they reduce their intake of saturated fat, and even the obese are usually unable to reduce their energy intake permanently and will seek compensatory sources of energy.

One alternative source of energy is alcohol. Indeed, people who meet guidelines for dietary fat often have fairly high alcohol intakes (13), but few would advocate this as a means for reducing fat intake. Protein intake also tends to rise when fat intake falls; lean steaks and cottage cheese are typical high-protein alternatives for high-fat foods and North Americans may nowadays report protein intakes as high as 18% of energy (14). Replacement of saturated fats by dietary protein lowers plasma low-density-lipoprotein (LDL) concentrations while avoiding the rise in very-low-density lipoprotein (VLDL) and fall in high-density lipoprotein (HDL) associated with high-carbohydrate diets (15–17). However, there is some con-

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cern that high-protein diets may favor calcium loss (18) and thus may increase the risk of osteoporotic fractures. The long-term health benefits of high-protein diets are therefore unclear, and diets high in protein are not an established safe alternative for diets high in saturated fat.

The most widely investigated alternatives for saturated fat are carbohydrates on the one hand and various vegetable oils rich in mono- or polyunsaturated fatty acids on the other hand. The remainder of this review will deal with these foods.

### EFFECTS OF CARBOHYDRATES ON SERUM LIPOPROTEINS

Low-fat diets produce low plasma cholesterol concentrations. However, we now know that part of the fall in cholesterol is due to a fall in HDL. Lowering of HDL concentrations by a high-carbohydrate diet was reported by Levy et al (19) already in 1966 and has been a consistent finding in dietary trials ever since. We combined data from 27 well-controlled trials encompassing 682 subjects and found that HDL cholesterol fell by 0.012 mmol/L (0.5 mg/dL) for every 1% of energy from saturated fatty acids that was replaced by carbohydrates. Meta-analyses by Hegsted et al (20) and by Yu et al (21) led to similar conclusions. Thus, carbohydrates lower not only LDL but also HDL and the predicted net effect of these changes on coronary risk is zero (3). In contrast, replacement of saturated fats by unsaturated oils increases the ratio of HDL to LDL in plasma and reduces the predicted coronary risk (3). The effect of carbohydrates on HDL is not restricted to sugars but is found also with diets high in complex carbohydrates, as illustrated in Figure 1 and Figure 2.

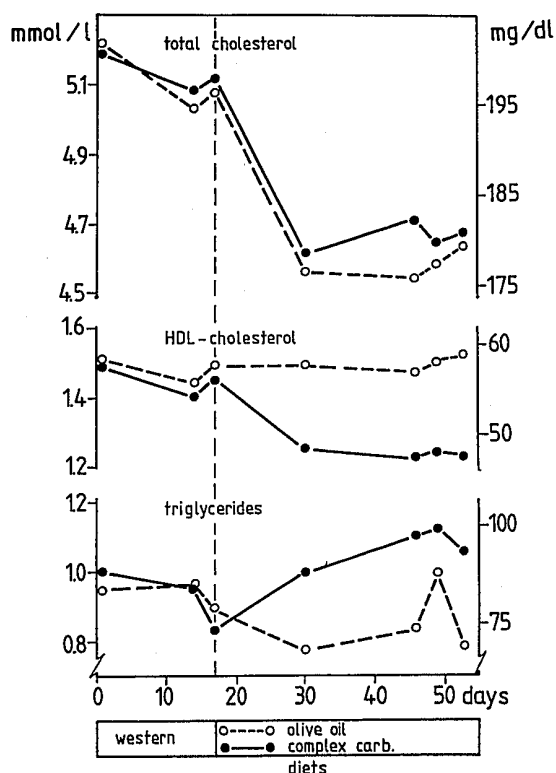
It has been suggested that the effect of carbohydrates on HDL seen in short-term metabolic trials is transient, but there is a wealth of data contradicting this. Several metabolic trials have studied changes in HDL as a function of fat and carbohydrate intake for periods from 3 mo up to 1 y, and they show that the fall in HDL persists (14, 23–25) (Figure 2). Epidemiologic studies show also that chronic intake of a high-carbohydrate diet is associated with lower concentrations of HDL, both for free-living individuals eating self-selected diets (26, 27) and for population means (28–30).

### DOES HDL MATTER?

An important question is whether HDL particles act against atherosclerosis themselves or whether they are merely indicators of the activity of some other factor that shields against atherogenesis. The inverse association of HDL—or  $\alpha$ -cholesterol, as it was known at the time—with ischemic heart disease was first reported in the early 1950s (31, 32), but it was not until 1975 that the importance of HDL was widely appreciated (33). Since then, evidence for a causal role of serum HDL concentrations in reducing cardiovascular risk has continued to accumulate. This evidence is derived from several sources (Table 1).

### Epidemiology

The epidemiologic evidence for an inverse association between HDL concentrations and cardiovascular disease is remarkably strong and consistent (34–36). The association is not



**FIGURE 1.** Mean serum total and HDL cholesterol and serum triacylglycerol as a function of fat intake in student volunteers. All 48 participants first received a Western diet that provided 38% of energy as fat, of which 20% was saturated. Over the next 36 d, 12 men and 12 women received a diet high in olive oil providing 41% of energy from fat (○) and another 12 men and 12 women a diet high in complex carbohydrates that provided 22% of energy as fat and 60 g dietary fiber/d (●). Reproduced with permission from The Lancet Ltd (22).

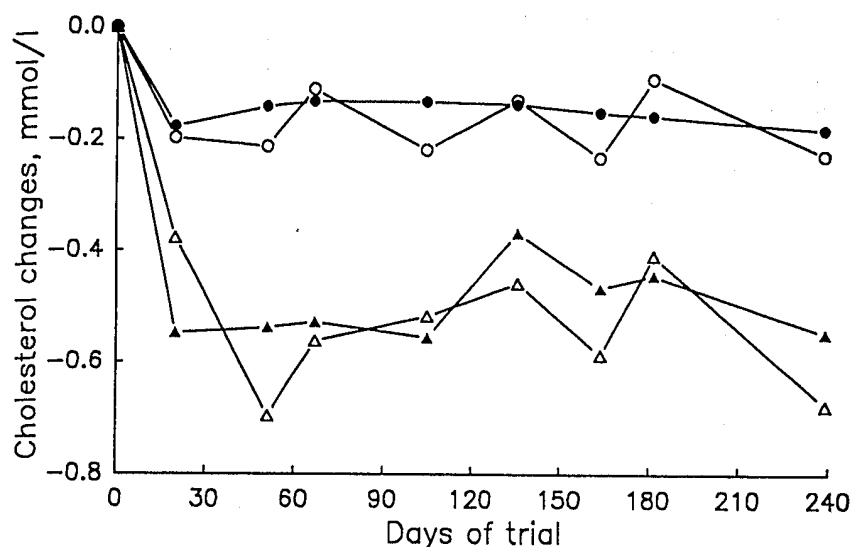
limited to populations with high LDL concentrations but is seen also in populations with low LDL concentrations such as the Japanese (37–39). Almost anything that lowers HDL raises ischemic heart disease risk; examples are smoking, obesity, lack of physical activity, abstinence from alcohol, and being a male.

### Genetics

Premature atherosclerosis is seen in several, although not all, inherited low-HDL syndromes, especially those in which LDL concentrations are normal (40, 41).

### Controlled drug trials

No trials have yet been reported of drugs that exclusively raise HDL without affecting LDL. However, some of the drugs tested in controlled clinical trials affected HDL as well as LDL concentrations. Post hoc analyses suggested that such drug-induced changes in HDL affected the risk of coronary disease independently of the effect on LDL. With drugs that raise HDL, a reduction in ischemic heart disease incidence was seen in proportion to the increase in HDL concentration (42). The reverse effect was seen in a trial of probucol, a cholesterol-lowering agent that lowers both LDL and HDL. In the femoral atherosclerosis study of the ProbucoL Quantitative Regression Swedish Trial, inclusion of probucol in the treatment regimen



**FIGURE 2.** Changes in least-squares-mean values for serum total cholesterol (lower curves, triangles) and HDL cholesterol (upper curves, circles) in 18 men (closed symbols) and 12 women (open symbols) who for 8 mo received a diet low in fat (26% of energy) and high in complex carbohydrates and fiber (50 g/d). The initial diet ( $t = 0$ ) provided 37% of energy as fat. A concurrent control group of 25 subjects showed no changes in total or HDL cholesterol (data not shown). Reproduced with permission from Macmillan Press Limited (23).

unexpectedly caused more rather than less atherosclerosis of the femoral artery as determined by angiography (43). This result could be explained by the effect of probucol on HDL; probucol-induced decreases in HDL were significantly correlated with decreases in lumen volume of the femoral artery and thus with enhanced atherosclerosis (43). Finally, chronic ingestion of the antiepileptic medicine phenetoin, which powerfully elevates HDL, was associated with markedly lower rates of ischemic heart disease mortality (44).

#### Animal studies

Weekly injection of HDL protein over a period of 8 mo strikingly reduced the extent of atherosclerosis in cholesterol-fed rabbits (45). Introduction of the gene for human apolipoprotein A-I, the major protein component of HDL, into atherosclerosis-prone mice markedly reduced the extent of atherosclerosis and the protective effect was proportional to the rise in HDL induced by the genetic manipulation (46). Introduction of the gene for human cholesterol ester transfer protein, which removes cholesterol from HDL and reduces HDL concentrations, led to accelerated atherosclerosis (47). Such experiments suggest that high HDL concentrations are not just an indicator of some underlying protective process but are directly involved in protecting the arterial wall from atherosclerosis in

**TABLE 1**

Types of evidence suggesting that reducing HDL concentrations will increase the risk of cardiovascular diseases

- 1) Epidemiologic associations are strong and universal; almost anything that raises HDL lowers ischemic heart disease risk
- 2) Inherited low HDL concentrations are frequently associated with premature ischemic heart disease
- 3) In drug trials, raising HDL lowers atherosclerosis risk and lowering HDL raises risk
- 4) In animals, overexpressing apolipoprotein A-I or infusing HDL protein reduces atherosclerosis

experimental animals. They also imply that any intervention that lowers HDL will increase atherosclerotic risk.

Thus, there is a wealth of circumstantial evidence suggesting that HDL is causally involved in atherosclerosis and that reducing plasma HDL concentrations increases the risk of cardiovascular disease. The final answer will have to come from controlled clinical trials, but the present evidence is too substantial to be dismissed.

#### DO HIGH-CARBOHYDRATE DIETS HAVE OTHER BENEFITS?

##### Weight reduction

Low-fat diets could conceivably provide other benefits that offset their negative effect on HDL. One of these is weight loss. Indeed, adult populations or population groups that subsist on low-fat diets are often quite lean, and this may cancel out the effect of such diets on HDL. Knuiman et al (28, 48) reported that persons following a macrobiotic diet had HDL concentrations similar to those of their omnivorous countrymen despite a diet low in fat and high in carbohydrates. In multivariate analysis this effect could largely be explained by the extremely low body mass index of persons consuming macrobiotic diets (28, 48). It would, however, be a mistake to expect the same effect from low-fat diets in the general public. There is little evidence that low-fat products as available nowadays result in substantial weight loss. The typical low-fat items on supermarket shelves are not the seaweed and brown rice favored in macrobiotic diets; the food industry provides a large range of foods that are low in fat but are otherwise highly appetizing and similar to their high-fat counterparts.

The elegant model of Flatt (49) predicts that low-fat diets should induce weight loss, and some (50)—although not all (51)—short-term experiments support this view. However, the acid test of such theories is long-term controlled trials, and the outcomes of these in terms of weight loss have been disap-

pointing. Long-term trials of low-fat diets have resulted in decreases in body weight of  $\approx 0.4$ – $2.6$  kg relative to control diets (14, 52–55). Most of the loss was achieved in the first few months, and weight loss typically ceased thereafter. The reduction in body weight in such trials was usually insufficient to compensate for the HDL-lowering effect of the high-carbohydrate diet (14, 25). Indeed, Leenen et al (56) in a well-controlled trial showed that in obese subjects a massive reduction in body weight (13.2 kg, 10.9 of which was fat) increased HDL cholesterol by only 0.11 mmol/L, or 0.008 mmol/L for each kilogram of body weight lost.

This figure agrees well with the longitudinal data of Berns et al (57), who found that in young men followed over a 10-y period, each one-unit increase in body mass index (in  $\text{kg}/\text{m}^2$ ) was associated with a decrease in HDL cholesterol of 0.024 mmol/L, which translates into  $0.007 \text{ mmol} \cdot \text{L}^{-1} \cdot \text{kg body wt}^{-1}$  gained. Thus, one would need to lose 12.5 kg body weight to offset the effect on HDL of an increase in carbohydrate intake of 10% of energy (3, 56) (Table 2).

Thus, the long-term trial data currently available (14, 52–55) suggest that a low proportion of fat in the diet by itself will not redress the 10–15 kg weight gain that many people in affluent countries experience between adolescence and middle age (57, 58). Also, the huge differences in body fatness between affluent and poor populations are probably not due exclusively to differences in the ratio of fat to carbohydrate in the diet: limited availability of attractive foods plus the need for hard physical labor are a more likely explanation.

This is not to say that we can now recommend diets containing any amount of fat and be confident that body weight will stay the same. The favorable effects of high-fat, high-oleic acid diets (10) on lipoproteins in persons with diabetes have caused the pendulum of dietary recommendations for diabetes to swing back from high-carbohydrate diets to diets containing more monounsaturated fat. However, the diets used in these studies provided 45% of energy as fat, and even though no one is recommending diets that are this high in fat, it needs to be stressed that their long-term effect on body weight is unknown.

### Societal issues

The present emphasis of nutrition guidelines on diets low in total rather than just saturated fat rests partly on scientific data, but nonscientific issues have also played a role. First, the low-fat concept is simple to communicate; it is easier to teach people that fat is bad than to explain the intricacies of the various types of fatty acids. Second, a campaign against total fat will receive wider support in society because various economic interests are more or less equally affected and producers

of meat, dairy products, and tropical oils do not feel as much singled out as when saturated fat is the only target.

One can sympathize with the educators who have to communicate difficult concepts to a public already overloaded with information, and with farmers and food producers who have always tried to provide foods that they considered wholesome and nutritious to the public and who now encounter huge problems in adapting their products to dietary guidelines. However, such considerations water down the scientific contents of the nutritional message and in the end do the public a disservice.

### CONCLUSION

There are some indications that high-carbohydrate, high-fiber, low-fat diets may help to prevent ischemic heart disease, diabetes, and obesity. However, the evidence for each particular disease is soft. Rules for the attachment of ropes in mountaineering state that five insecure anchor points together never equal a single secure one: under stress all five may fail (59). Anchoring of nutrition policy should follow the same rule. The potential of low-fat diets for the prevention of a host of diseases is now being investigated in properly controlled trials (60). As long as that evidence is not in, effects of low-fat diets on obesity and other conditions should not play a decisive role in formulating nutrition policy. Guidelines for reducing fat intake should therefore aim specifically at saturated fatty acids, and replacement of saturated fats by unsaturated oils is as valid an option as is replacement by carbohydrates.  $\square$

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**TABLE 2**  
Estimated changes in HDL cholesterol concentrations with weight loss and with replacement of dietary fat by carbohydrate

| Intervention                                 | Change in HDL cholesterol            |
|--|--------------------------------------|
| Weight loss of 10 kg                         | 0.08 mmol/L (3 mg/dL) <sup>1</sup>   |
| Fat intake reduced from 40% to 20% of energy | –0.21 mmol/L (–8 mg/dL) <sup>2</sup> |

<sup>1</sup> Based on experimental data of Leenen et al (56).

<sup>2</sup> Based on the meta-analysis of Mensink and Katan (3) and assuming that the reduction in fat intake is made up of 12% of energy from saturated fat and 4% each of mono- and polyunsaturated fat.

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