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Nutrition Bytes

Title

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Permalink

<https://escholarship.org/uc/item/8qg6r106>

Journal

Nutrition Bytes, 12(1)

ISSN

1548-4327

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Publication Date

2007-06-18

Peer reviewed

Abstract:

The role of proper diet in cardiovascular health is one which has been heavily debated over the last century. In 1908, Ignatowski produced atherosclerotic lesions in rabbits with a diet high in cholesterol and saturated fat. He subsequently fed the rabbits cholesterol alone, which produced identical lesions (1). During the early 1950s, controlled feeding studies showed that saturated fatty acids and, to a smaller extent, dietary cholesterol increased serum cholesterol in human subjects (2). Later, epidemiologic studies found that increases in serum cholesterol predicted increased risk of coronary artery disease (CAD) in humans. These findings led to the development of the 'diet-heart hypothesis', which assumes a primary role of dietary saturated fat and cholesterol in the causation of atherosclerosis and CAD. Currently, the relationship between high serum cholesterol and CAD is well established, however, the role of diet in both the prevention and treatment of CAD remains controversial. Utilizing the medical literature, 3 dietary tenets have been established which are strongly associated with decreased risk of coronary artery disease: Consumption of good fatty acids (polyunsaturated fats, omega-3 fatty acids), multiple fruits and vegetables, and non-refined whole grains.

Keywords: diet, heart, coronary artery disease

The Diet-Heart Hypothesis: a critical appraisal of the relationship between diet and coronary artery disease

Introduction

The role of proper diet in cardiovascular health is one which has been heavily debated over the last century. In 1908, Ignatowski produced atherosclerotic lesions in rabbits with a diet high in cholesterol and saturated fat. He subsequently fed the rabbits cholesterol alone, which produced identical lesions (1). During the early 1950s, controlled feeding studies showed that saturated fatty acids and, to a smaller extent, dietary cholesterol increased serum cholesterol in human subjects (2). Later, epidemiologic studies found that increases in serum cholesterol predicted increased risk of coronary artery disease (CAD) in humans. These findings led to the development of the 'diet-heart hypothesis', which assumes a primary role of dietary saturated fat and cholesterol in the causation of atherosclerosis and CAD. Currently, the relationship between high serum cholesterol and CAD is well established, however, the role of diet in both the prevention and treatment of CAD remains controversial. Utilizing the medical literature, the individual roles of specific foods and their effects on cardiovascular health have been critically reviewed and presented here.

Dietary Fat Intake

Multiple controlled feeding studies addressing the effects of different dietary fatty acids on serum cholesterol levels have been examined in various meta-analyses (3-7). These analyses confirm that saturated fatty acids increase and polyunsaturated fatty acids decrease total and low-density lipoprotein cholesterol (LDL-C). Saturated, monounsaturated and polyunsaturated fatty acids all elevate high-density lipoprotein cholesterol (HDL-C) when they replace dietary carbohydrates. This effect is usually more pronounced with saturated fatty acids. In addition, triglyceride levels rise when dietary fatty acids are substituted with carbohydrates. By replacing saturated fat with carbohydrates, both the LDL-C and HDL-C decrease proportionately, leaving little effect on the LDL-HDL ratio. Thus, elevated triglycerides, plus a static LDL-HDL ratio would have little positive effect on CAD risk, however, when monounsaturated or polyunsaturated fats replace saturated fat, LDL-C decreases and HDL-C changes only slightly (8).

In controlled metabolic studies, trans-fatty acids (present in vegetable shortenings, deep fried foods, stick margarine) were found to raise LDL-C levels and lower HDL-C relative to cis-unsaturated fatty acids. The increase in the ratio of total cholesterol to HDL-C for trans-fat is approximately twice that for saturated fat (8) (9). The best epidemiologic data available on the possible relationship between saturated fat and CAD are from prospective cohort studies, the largest and most detailed being the Nurses' Health Study cohort (10). The Nurses' Health Study found that higher intakes of trans-fat were associated with increased risk of CAD. This was also true of increased saturated fat in the diet, but to a lesser extent. In contrast, higher consumption of nonhydrogenated

polyunsaturated and monounsaturated fats were associated with decreased risk. Since the effects of different types of fat were opposing, total fat as percentage of energy was not significantly associated with CAD risk. Dietary cholesterol and modest egg consumption of 1 egg/day, were not significantly associated with CAD or stroke, either.

Further compounding the findings of the Nurses' Health Study were 3 other large prospective studies which found an increased risk of CAD with increased trans-fat consumption (11-13). When combining the results from these 4 prospective clinical trials, the relative risk of CAD associated with a difference of 2% energy in trans-fatty consumption (assessed at baseline) was 1.25 (95% confidence interval, 1.11-1.40). In a more current population-based case-control study of 179 cardiac arrest patients and 285 controls, higher red-cell membrane levels of trans-fatty acids, particularly trans-isomers from partially hydrogenated vegetable oils, were associated with significantly increased risk of primary cardiac arrest (14).

Omega-3 fatty acids have been shown to decrease the risk of CAD by preventing cardiac arrhythmia, decreasing thrombus formation, lowering serum triglyceride levels and improving endothelial dysfunction (15) (16). A systematic review of over 11 studies regarding an inverse association between fish intake and cardiac mortality were published before the year 2000, and 4 additional prospective cohort studies have been published since. These studies concluded that the inverse association was stronger in the case of fatal CAD than for nonfatal myocardial infarction. In addition, the benefits of fish intake were most evident in populations with higher than average risk of CAD (17).

Alpha-linoleic acid (ALA), an omega-3 fatty acid found in flaxseed, canola, and soybean oils, can be converted to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in humans and, thus, may have a role in prevention of CAD (8). An inverse association between ALA consumption and risk of fatal CAD was observed in multiple prospective cohort studies (11,12,18,19). In one cohort study of women, frequent intake of oil and vinegar salad dressing (a good source of ALA in US diets) was associated with a significantly lower risk of fatal CAD (18).

These trials strongly support the protective effects of omega-3 fatty acids, including both ALA and fish oil, in secondary prevention of CAD. However, the role of fish oil supplements in primary prevention of CAD has not been tested (18).

Low-fat/high-carbohydrate vs. Low-carb/high-protein Diets

The low-fat-high-carbohydrate (LF-HCarb) diet, the mainstay of the U.S. Department of Agriculture's (USDA) war against CAD, has shown increasing weakness under a growing mountain of evidence against its effectiveness as a heart-healthy diet. Hu et al. noted that LF-HCarb diets were widely recommended to reduce the risk of CAD by reducing LDL-C by limiting dietary fat. However, because of its high carbohydrate content, LF-HCarb diets also decrease HDL-C and increase triglycerides, both being well-established independent risk factors for CAD (10).

Yancey et al. noted: the current epidemic of obesity, type II diabetes, and the metabolic syndrome (all 3 being major CAD risk factors) in retrospect seems to be, in part, the inevitable result of the LF-HCarb diet and its absent warnings about unlimited Carb intake. These unfortunate nutritional approaches were promoted aggressively by the profession and by the most credible medical organizations and institutions, in concert with the USDA and the food industry, in the absence of any definitive long-term evidence of its efficacy in CAD prevention (21).

While strong concerns remain regarding the safety of low-carbohydrate-high-protein (LCarb-HP) diets (potentially high saturated fat intake, nutrient deficiencies) as they relate to CAD, there is undeniable short-term evidence that they work in improving lipid profiles, weight loss and fasting glucose levels in both diabetic and non-diabetic overweight patients (22-25). These facts alone warrant further investigation of LCarb-HP diets and their long-term effects on glycemic control, weight loss and CAD.

Certain Foods and Dietary Patterns

The relationship between consumption of specific foods or overall dietary trends and risk of CAD has been addressed in recent studies. These analyses are valuable in making heart-healthy recommendations to the general public as well as evaluating additional diet-heart hypotheses (8). An example would be the replacement of red meat in the diet with chicken and fish, which has been associated with decreased risk of CAD (26). Also, an inverse association between nut consumption and risk of CAD has remained consistent in multiple prospective studies (27-32). This data further reinforces the importance of distinguishing between certain types of fat. Nuts are high in monounsaturated and polyunsaturated fats, which lower LDL-C.

Despite long-held widespread public assumption, the beneficial effects of fruits and vegetables have only recently been shown empirically to decrease CAD risk (11,12,33-38). In the largest study, including 84,251 women and 42,148 men, Joshipura et al reported a significant inverse association between consumption of fruits and vegetables, particularly green leafy vegetables and vitamin C-rich fruits and vegetables, and risk of CAD.

More recently, several authors have reported the role of overall dietary patterns in predicting long-term risk of CAD (39). In these analyses, a dietary pattern characterized by high fruits, vegetables, legumes, whole grains, poultry, and fish was associated with lower risk of CAD, whereas a more “Western” pattern comprised of high intake of red and processed meats, sweets and desserts, potatoes, french fries, and refined grains was associated with an increased risk, independent of lifestyle factors (40) (41).

Diet and Lifestyle

The combination of multiple dietary factors is more powerful than a single factor alone. The Nurses’ Health Study showed that a diet high in cereal fiber, marine omega-3 fatty

acids, and folate and low in trans-fat and glycemic load, with a high ratio of polyunsaturated fat to saturated fat, strongly predicted decreased risk of CAD (8) (42).

In addition, the Nurses' Health Study estimated that 82% of CAD events within the study cohort could be prevented by moderate diet and lifestyle modifications (42). Among the non-smokers studied, up to 74% of coronary events might have been avoided by maintaining a healthy body weight, regular exercise for a half hour or more daily, eating a healthy diet, and consuming a moderate amount of alcohol.

A multifactorial primary CAD prevention trial, the Oslo Heart Study, has yielded strong evidence as well. It found that stopping smoking and increasing the ratio of polyunsaturated to saturated fats in the diet reduced CAD incidence by 47% among men with higher-than-average serum cholesterol levels (43). Additional large multifactorial diet/lifestyle trials remain underway and will hopefully provide greater insight into CAD prevention.

Conclusions

Strong evidence from epidemiologic studies, meta-analyses and clinical trials over the course of decades have come to show 3 major dietary tenets with regard to prevention of CAD: substitute unsaturated fats (particularly polyunsaturated fat) for saturated and trans-fats; consume a fair amount of omega-3 fatty acids in the form of fish oil or plant sources; and consume a diet high in fruits, vegetables, nuts, and whole grains and low in refined grains (8). Combining these approaches can confer greater benefits than any single one of them alone. In addition, lowering the percentage of energy from total fat in the diet is unlikely to improve lipid profile or reduce CAD incidence.

Being overweight is an important way in which diet can influence the risk of CAD. Although reduction in percentage of calories from dietary fat intake is regularly recommended for patients who desire to lose weight, long-term clinical trials have shown no strong evidence that lowering dietary fat intake can lead to weight loss (44) (45). Mildly hypocaloric moderate-fat diets, which allow for a variety of foods, can have better long-term success and compliance than a low-fat diet (46). This, along with several low glycemic index, high protein diets are being currently looked at long term for their potential efficacy in weight management as well (8).

Current dietary guidelines, such as those outlined by the USDA, emphasize target intake of specific macronutrients (i.e. <30% energy from fat), however, these numerical guidelines are not based on solid scientific evidence. In addition, the public finds it difficult to make dietary changes based on these criteria. This type of rigidity in dietary intake of macronutrients results in noncompliance and poor dietary habits rather than healthy change. Multiple options exist for the creation of attractive and heart-healthy diets, with differing amounts of fat and carbohydrates, as long as the diet embraces healthy types of fat and carbohydrates and is predicated upon appropriate balance in energy intake and expenditure (8).

Clear evidence shows diets which contain nonhydrogenated unsaturated fats as the predominant type of dietary fat, whole grains as the main carbohydrate source, multiple fruits and vegetables, and multiple weekly servings of omega-3 fatty acids can offer significant protection against CAD (20). These dietary practices, accompanied with regular physical activity, cessation/avoidance of smoking, and maintaining a healthy body weight, may prevent the majority of cases of cardiovascular disease in Western society.

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