Omega-3 Fatty Acid

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Abstract

Objective: The purpose of this literature review is to compare and contrast recent literature regarding omega-3 fatty acid supplementation into an individual's daily diet. This review will analyze how and why omega-3 fatty acid can be beneficial in both prevention of diseases and overall health. Should people today make more of an effort to consume omega-3 fatty acids? This paper will emphasize the affect of the ratio of essential fatty acids we consume and how it affects our health. Also investigated will be the role of how flaxseed supplementation can benefit our diet.

Data Collection: The resources utilized included indexed/referenced journal articles, text and reference books, and Internet websites. Pubmed, Ebscohost, Chiroweb, Chiroaccess, and Mantis were databases used to find journal articles and publications related to the topic of omega-3 fatty acids and health. The Mobius library catalog was utilized at the Learning Resource Center of Logan College of Chiropractic to find books relating to the topic of fatty acids and health.

Results: The keyword search for omega-3 fatty acids, turned up thousands of articles regarding their consumption in the diet. Appropriate nutritional guidelines for the benefit of omega-3 fatty acid in our diets have been under debate by leading researchers in the field. The following conclusions represent a consensus of research regarding how balancing out the fatty acid intake with omega-3 fatty acids can help several health conditions.

Conclusion: Current literature emphasizes a practical dietary approach to help balance out the omega-6 fatty acids with the omega-3 fatty acids. Our ancestors lived with a daily ratio of the two fatty acids as 1:1. Today's society is faster paced, so people select fast foods or convenient foods that are loaded with omega-6 fatty acids. Research shows that today the average person consumes a ratio of 100:1 to 25:1 of omega-6 fatty acids to omega-3 fatty acids. According to research the omega-6 fatty acids overpower the omega-3 fatty acids and make them inactive. This is leading to several different health problems including: childhood asthma, depression, obesity, skin problems, heart disease, migraines, inflammatory diseases, arthritis, etc…

Key Words: Omega-3 fatty acids, Essential Fatty Acids, Nutrition, Flaxseed, Heart disease.

Introduction

Civilization has certainly changed our lifestyles. Yet, the basic bodily needs have not changed since the beginning. Balance in life and in our body is key. Our health relies upon the basic needs of fresh air, clean water, sunshine, exercise and a common sense balance of proteins, carbohydrates and fats (1,2).

However, society in general has become overweight, and we immediately tend to jump on the bandwagon of condemning the consumption of foods categorized in the "fats" food group. The term "fats" will sometimes send shivers of repulsion into the minds of those who maintain a strict and uncompromising diet plan, swearing off all foods from this necessary food group. "Fats" has somehow become the forbidden four-letter word and in our quick desire to eliminate fat from our diets, we have also tended to forget some of the necessary functions of what is known as "essential fats"(1). The terminology is certainly misleading because a certain amount of fat in the diet is absolutely essential for our health (1). Learning about "good fat" and "bad fat" is crucial to assist in making healthy choices. Cutting out all fat in your diet is not a healthy choice.

Our diet has changed significantly since our cave-dwelling ancestors inhabited the earth. Certainly the "good old days" were not as glamorous as we have it today, with science, technology and the luxury of endless food, but some how, the hunter-gatherer lifestyle has shown innate understandings of the body's need for a balanced diet (3,4). This is where we have started to gain some understanding to the importance of essential fatty acids.

Discussion

Overview

Our body can make most of the fatty acids it needs from the carbon, hydrogen, and oxygen atoms provided by food. These are called *nonessential fatty acids* because it is not essential for us to consume them in the foods we eat.

However, there are polyunsaturated fatty acids that the body cannot manufacture, and these are called the *essential fatty acids*. They are necessary for good health, but we can only get them from food. There are two main groups of essential fatty acids: the omega-3 oils and the omega-6 oils (4). The numbers "3" and "6" refer to the place where the first kink in the carbon chain occurs. Linoleic acid is the primary member of the omega-6 family, which the body can convert into the longer-chain arachidonic acid (AA). Like wise, alpha linolenic acid (ALA) is the primary omega-3, which the body can convert into eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Long-chain omega-3 and omega-6 fats form the membranes of every cell in the body and influence every process in the cell (4).

The difference between the two groups is that the omega-3 oils are more polyunsaturated than the omega-6 oils. That is, the omega-3 oils have fewer hydrogen atoms—and consequently, more kinks – in their molecules. This means that the omega-3 oils are much more liquid than the omega-6 oils at a given temperature.

Due to lifestyle and dietary habits with fast food and convenience foods, the general public has consumed a diet rich in fats (3,5). A common reaction then is to eliminate all or the majority of fat in the diet which is equally bad. The problem exists in

the type of fat we ingest – too much saturated fat – known as "bad fats"—the type that clogs arteries and raises cholesterol levels (5).

The diet of our ancestors included a good balance of essential fatty acids. Essential fatty acids are grouped into two families, the omega-6 fatty acids and the omega-3 fatty acids. The omega-3 fatty acid group is considered the "good fats" or known as the polyunsaturated fats (4). Understanding the difference between the omega-6 and the omega-3 fatty acids is very important to know. It is more than just the difference in their numbers that should be of concern.

Omega-6 fatty acids (found in vegetable oils with high proportions of linolenic acid) are best used by the body in a range of anywhere from a 4:1 to a 1:1 proportion with the omega-3 fatty acids (3). We need both omega-3 and omega-6 fatty acids. Yet, an excess of omega-6 fatty acids can have severe consequences. Many scientists believe that a major reason for the high incidence of heart disease, hypertension, diabetes, obesity, and some forms of cancer is the extreme imbalance between our intake of omega-6 and omega-3 fatty acids (3).

Our ancestors evolved on a diet with a 1:1 ratio of omega-6 to omega-3 fatty acids. Dietary changes over the last few centuries have changed this ratio anywhere from 20:1 to 25:1 (3,5). This is clearly a set up for trouble, and addresses many of today's chronic health problems that are of concern.

One of the primary reasons we ingest too much of the omega-6 fatty acid groups in our diet is the mass use of vegetable oils. This practice is so common that practically every fried food and snack food available has been cooked in soybean, corn, sunflower, or canola oil (6). These oils are usually processed by hydrogenation. This changes their

molecular structure so they are basically good for frying foods at a high temperature and providing a lengthy shelf life in the grocery store (6). Unfortunately, these molecular properties in the omega-6 fatty acids promote inflammation, blood clotting and tumor growth (5).

The omega-3 fatty acids act entirely opposite. But, when the omega-6 fatty acids are disproportionately higher, the omega-3 fatty acids cannot compete with the omega-6 activity. When in balance, they work in concert, making sure for every action; there is a reaction, helping to maintain stability in the body (5).

Historical Background

Evidence that omega-3 fats are critical to health first surfaced in studies of the Inuit (Eskimos) of northern Canada and Greenland (7,8,9). Eating a traditional diet of fish and seal blubber, these people obtained up to two thirds of daily calories from fat. Yet heart disease was rare (7). The Eskimos' blood was usually neither sticky nor thick, and cholesterol and fat levels in the blood were normal (4). Their blood took a very long time to clot. These discoveries explained the low rate among these people of heart attacks, and the lack of blood clots in their arteries (4). Investigators believe that the high level of omega-3 fats in fish protected the Inuit against heart disease. This is what started the intense research on how the variants in the ratio of omega-6 and omega-3 fatty acids are critical to our health (7,8,9).

A prevention study of 11,324 patients, done by the Mid America Heart Institute of Saint Luke's Hospital and Department of Medicine at the University of Missouri in Kansas City, showed a 45% decrease in the risk of sudden cardiac death and a 20% reduction in all-cause mortality in the group taking 850mg/day of omega-3 fatty acids (8).

This study also revealed that these fatty acids had potent anti-inflammatory effects and may also be antiatherogenic. Higher doses of omega-3 fatty acids can lower elevated serum triglyceride levels; 3 to 5 g/day can reduce triglyceride levels by 30% to 50%, minimizing the risk of both coronary heart disease and acute pancreatitis (8).

Dewailly et al. did a study, which consisted of 426 Inuit aged 18-74 years old. Plasma samples were analyzed for phospholipid fatty acid composition. The results showed that omega-3 fatty acids were positively associated with HDL cholesterol concentrations and inversely associated with triacylglycerol concentrations and the ratio of total to HDL cholesterol (7). The study concluded that consumption of marine products, the main source of EPA and DHA, appears to beneficially affect some cardiovascular disease risk factors. The traditional Inuit diet, which is rich in omega-3 fatty acids, is probably responsible for the low mortality rate from ischemic heart disease in this population (7). The plasma phospholipids of the Nunavik Inuit, who traditionally consume large amounts of marine foods, contained relatively high concentrations of omega-3 fatty acids. Older Inuit had higher concentrations of omega-3 than did younger Inuit, reflecting their higher intakes of marine foods. Modifications in the Inuit diet, including reductions in marine product consumption, have taken place over the past decades, especially in younger Inuit. This decline in marine food consumption is attributable in part to the greater availability of market foods in communities (7).

Another study done by McGrath-Hanna et al. also found that a change in the traditional diets, from fish oil diets, of people living in the Arctic and Sub arctic environments has lead to increased health problems, such as obesity, cardiovascular disease, and diabetes, while the mental health of circumpolar peoples has also declined

substantially during the same time period (10). The decline in mental health is characterized by increased rates of depression, seasonal affective disorder, anxiety, and suicide that now often occur at higher rates than in lower-altitude populations. Studies in non-circumpolar peoples have shown that diet can have profound effects on neuronal and brain development, function, and health (10).

Importance of omega-3 fatty acids

Dietary fat, besides providing energy to the body, controls several vital functions such as circulation, immune system and flexibility of body membranes and cells by converting to hormone-like chemicals in the body called eicosanoids (11). The eicosanoids are highly potent chemicals produced only in minute quantities by the body cells whenever and wherever they are needed; they cannot be stored in the body. Many eicosanoids have opposing effects and by creating different quantities of these eicosanoids, the body maintains a wonderful balance in its various functions. Many diseases such as heart attack, stroke, cancer, migraine, arthritis, and hypertension are now attributed to an imbalance in the production of eicosanoids (11).

Eicosanoids are mainly formed in the body by arachidonic acid (AA), an omega-6 fatty acid found in vegetable oils. Other omega-6 and some omega-3 fatty acids first convert to AA and thus indirectly contribute to production of eicosanoids (11). Eicosanoids are also synthesized from omega-3 acids and are distinct from eicosanoids synthesized from omega-6 fatty acids. And it is this difference in the activity of the two types of eicosanoids that makes fish so good for our health (11).

Eicosanoids are divided into two families: the prostaglandins (PGs), which are made by an enzyme called cyclooxygenase; and the leukotrienes, which are made by an enzyme called lipooxygenase. Both families stimulate inflammation and contraction of muscles. Some drugs act by blocking cyclooxygenase enzyme so that PGs are not formed. For example, aspirin is recommended to reduce risk of heart disease because of its blocking of PG formation (11).

The omega-3 fatty acids are essential to life at every stage of life, even before birth. They are found in the membrane of every cell in the body and help to ensure that the cell membrane is ideally equipped to do its job. They play an important role as structural membrane lipids, particularly in nerve tissue and retina and are precursors to eicosanoids – highly reactive substances such as prostaglandins and leukotrienes that act locally to influence a wide range of functions in cells and tissues (4). Prostaglandins operate in most tissues of the body to regulate just about every bodily function, including:

- Regulating pressure in the eye, joints, and blood vessels, and mediating immune response
- Regulating bodily secretions and their viscosity
- Dilating or constricting blood vessels
- Regulating collateral circulation
- Directing endocrine hormones to their target cells
- Regulating smooth muscles and autonomic reflexes
- Being primary constituents of cell membranes
- Regulating the rate of cell division
- Maintaining the fluidity and rigidity of cellular membranes

- Regulating the inflow and outflow of substances to and from cells
- Transporting oxygen from red blood cells to the tissues
- Maintaining proper kidney function and fluid balance
- Keeping saturated fats mobile in the blood stream
- Preventing blood cells from clumping together (blood clots that can be a cause of heart attack and stroke)
- Mediating the release of inflammatory substances from the cells that may trigger allergic conditions
- Regulating nerve transmission and communication (4)

The omega-6 and omega-3 fatty acid groups each produce separate, distinct protaglandins with different functions. For good health, both types of fatty acids are needed, and in the right ratio. That vital balance is hard to achieve because omega-3 is often missing from the modern diet (4). When optimal amounts of essential fatty acids are added to the diet, many of the body's organs – including the skin, heart, kidney, liver, and reproductive organs – function better, and the body's ability to fight both cancer and infections is improved (12)

Deficiency of Omega-3 fatty acids

Trouble is started when one fatty acid overpowers another. Clearly, the data shows we need to seriously increase omega-3 fatty acids in our diets. Omega-3 fatty acid deficiencies are increasingly prevalent with young children. Children low in omega-3 fatty acids are significantly more likely to be hyperactive, have learning disorders and to display behavioral problems (4,13). There has also been a connection with a deficiency of omega-3 fatty acids and an increase in the risk of asthma in kids (14).

In the general public, studies have linked omega-3 fatty acid deficiencies to chronic health problems of diabetes, cancer, arthritis, inflammatory diseases, depression, bipolar disorder, heart disease, hypertension, reproductive problems, memory problems, weight gain and some allergies and skin conditions (3,13,15,16,17,18).

Researchers believe 60% of Americans are deficient in omega-3 fatty acids and approximately 20% of those have so little that test methods would not be able to detect even a trace in their blood (4).

Therefore, some signs and symptoms of being deficient in omega-3 fatty acids, could be any of the following:

- Skin problems, such as itching, flaking, peeling, and hair loss
- Headache, fatigue, restlessness, confusion, and general weakness
- Easy bruising, pain, inflammation, and swelling of joints
- Infertility, spontaneous abortion, and kidney problems (4)

Benefits of Omega-3 Fatty Acids

The biggest culprit when it comes to causing many serious diseases is the body itself. When an outside element enters the body, the immune system of the body gets to work to eliminate it; however, in the aftermath of the war with the foreign element, the body is left with chemicals that could bring symptoms of diabetes, cancer, arthritis, inflammatory diseases, depression, heart disease, weight gain, allergies, skin problems and many other unexplained diseases (11).

Omega-3 fatty acids also control disorders of the body's immune system as evidenced by Eskimos, who rarely show any of these disorders. The eicosanoids formed from omega-3 acids reduce the activity of the body's immune system; however, this

containment of the immune system is highly selective and does not affect the body's ability to fight-off infections and cancer (11). If these eicosanoids were to depress the immune functions indiscriminately, the body would quickly succumb to various diseases as has happened with AIDS, for which no treatment has so far been found. The selective action of omega-3 on the body's immune system actually enhances the infection-fighting ability of the body (11).

Inflammation of tissues is caused by various blood cells, such as monocytes and platelets, sticking to the site of injury and releasing chemicals. Since omega-3 fatty acids reduce the stickiness and chemical reactivity of these cells, inflammation, which results from arthritis and physical injuries, is defused (11).

Omega-3 fatty acids also alter the types of leukotrienes formed by omega-6 acids, which causes inflammation and hypersensitive reactions. Studies conducted at the Albany Medical College in the September 1986 issue of the Internal Medicine News show extremely beneficial effects of EPA (the omega-3 acid in fish) in treating rheumatoid arthritis (19). This study observed significant reduction in the number of tender joints in subjects treated with fish oil for only 14 weeks. Another study from the Harvard Medical School on 13 patients showed similar results. Omega-3 fatty acids have the ability to make cell membranes more "fluid" thus, in effect, "lubricating" the joints (19).

The symptoms of asthma are caused by eicosanoids, which fight foreign particles in the body or at times its own cells. Eskimos show extremely low incidence of asthma because of altered composition of eicosanoids (11). However, the fish oil therapy can be beneficial only in the early stages of asthma since once the allergic reaction has been

established, it is not possible to eliminate it. Eskimos benefit because they take omega-3 rich diets from infancy (11).

Fish oil can also reduce the collapse of lungs during severe allergic reactions, as observed in many studies on people fed high fish oil diets (14). The Department of Nutrition, Dietetics and Food Science at Curtin University of Technology in Western Australia conducted a study that was published in *Journal of Asthma* on the ratio of omega-6 to omega-3 fatty acids and childhood asthma. This study observed 2602 children. Half of the children were diagnosed with asthma by the age of eight, and the other children did not have asthma yet by the age of eight (14). The ratio of the omega-6 and omega-3 intake was recorded for each group. They found evidence for a modulatory effect of the dietary omega-6 fatty acid to omega-3 fatty acid ratio on the presence of asthma in children. The results provide evidence that promotion of a diet with increased omega-3 fatty acids and reduced omega-6 fatty acids is beneficial in protecting children against symptoms of asthma when warranted (14).

Recent studies have reported that anti-immune and vasodilation effects of omega-3 fatty acids relieved migraine pains for patients on high fish oil diets. Since migraine pains have a myriad of causes, not all of which may be affected by omega-3 fatty acids, highly variable effects of fish diet are noted in migraine patients. In one study done at the University of Cincinnati, College of Medicine, five out of six sufferers from migraine headaches, had fewer; less sever headaches when they took 20 grams of a commercial fish oil preparation in contrast to those on a placebo (11).

Several beneficial effects of a fish oil diet have been observed in Type II diabetic patients, who traditionally have a very high death rate from heart diseases (11). Even

short term treatment with concentrated fish oil results in a significant decrease in the blood triglyceride levels and an increase in the HDL levels, a combination highly beneficial to reducing the incidence of the blocking of arteries. The American Diabetes Association has found several important findings of the effect of fish oil in treating Type II diabetes. There is also evidence that omega-3 fatty acids directly affect insulin production and sensitivity of body cells to insulin. The low incidence of Type II diabetes in Eskimos may be also attributed, in addition to their high omega-3 intake, to the low amount of refined carbohydrates in their diets (11)

Lupus is a chronic disease of damagde blood vessels and kidney. The damage to blood vessels results in high blood pressure and plaque formation leading to heart attacks. The dietary omega-3 fatty acids produce eicosanoids, which interfere in the initiation and progression of lupus as observed in Eskimos and others who consume a high quantity of omega-3 fats (11).

A study done by Trak-Felermeier et al., at the Institute of Epidemiology in Oberschleissheim, Germany, assessed the relationship between dietary intake of selected foods and fatty acids with atopic disease prevalence in adults (17). In males, margarine intake and high ratio of omega-6 to omega-3 fatty acids were positively associated with hay fever. In females, a high intake of total fat, palmitoleic and oleic acids were positively associated with hay fever (17). Whilst an excessive intake of fat or imbalance in fat intake, particular of monounsaturated fatty acids, increased the risk for hay fever and allergic sensitization in females. Therefore, a diet higher in omega-3 fatty acids would help to reduce these symptoms (17).

A diet rich in omega-3 fatty acids has also been shown to decrease cancer cells. According to Leitzmann et al., in the *American Journal of Clinical Nutrition* in 2004, laboratory studies showed that omega-3 fatty acids inhibit and omega-6 fatty acids stimulate prostate tumor growth, but whether the dietary intake of these fatty acids affects prostate cancer risk in humans remains unclear (16). They evaluated the association between intakes of alpha-linolenic (ALA), eicosapentaenoic (EPA), docosahexaenoic (DHA), linoleic (LA), and arachidonic (AA) acids and prostate cancer risk. A cohort of 47,866 US men ages 40-75 years old with no cancer history in 1986 was followed for 14 years. During follow-up, 2965 new cases of total prostate cancer were ascertained, 448 of which were advanced prostate cancer (16). ALA intake was unrelated to the risk of total prostate cancer. EPA and DHA intakes were related to lower prostate cancer risk. LA and AA intakes were unrelated to the risk of prostate cancer. They concluded that increased dietary intakes of ALA might increase the risk of advanced prostate cancer. In contrast, EPA and DHA intakes may reduce the risk of total and advanced prostate cancer (16).

Several studies have also been done that showed how omega-3 fatty acids can be beneficial for cardiovascular health. Wijendran and Hayes at the Foster Biomechanical Research Lab in Waltham, Massachusetts did research on how the dietary intake of omega-6 fatty acid and omega-3 fatty acid balance affected cardiovascular health. Epidemiological and clinical studies have established that the omega-6 fatty acid, linoleic acid (LA), and the omega-3 fatty acids, linolenic acid (LNA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) collectively protect against coronary heart diseases (CHD) (18). LA is the major dietary fatty acid regulating low-density

lipoprotein (LDL-C) metabolism by down regulating LDL-C production and enhancing its clearance. Further, the available mass of LA is a critical factor determining the hyperlipemic effects of other dietary fat components, such as saturated and trans fatty acids, as well as cholesterol. By contrast, omega-3 fatty acids, especially EPA and DHA, are potent antiarryhthmic agents. EPA and DHA also improve vascular endothelial function and help lower blood pressure, platelet sensitivity, and the serum triglyceride level. The distinct functions of these two families make the balance between dietary omega-6 and omega-3 fatty acids an important consideration influencing cardiovascular health. Based on published literature describing practical dietary intakes, it is suggested that the consumption of 6% en LA, 0.75% en LNA, and 0.25% en EPA + DHA represents adequate and achievable intakes for most healthy adults. This corresponds to an omega-6/omega-3 ratio of 6:1 (18).

An article written by U.N. Das also found a benefit of omega-3 fatty acids and cardiovascular disease. He found that low rates of coronary heart disease are found in Greenland Eskimos and Japanese who are exposed to a diet rich in fish oil. Suggested mechanisms for this cardio-protective effect focused on the effects of n-3 fatty acids on eicosanoid metabolism, inflammation, beta-oxidation, endothelial dysfunction, cytokine growth factors, and gene expression of adhesion molecules. But, none of these mechanisms could adequately explain the beneficial actions of omega-3 fatty acids (15). One attractive suggestion is a direct cardiac effect of omega-3 fatty acids on arrhythmogenesis. Omega-3 fatty acids can modify sodium channels by directly binding to the channel proteins. Omega-3 fatty acids can inhibit the synthesis and release of pro-inflammatory cytokines such as tumor necrosis factor (TNF) and interleukin-1 (IL-1) and

IL-2 that are released during the early course of ischemic heart disease (15). These cytokines decrease myocardial contractility and induce myocardial damage, enhance the production of free radicals, which can also suppress myocardial function. Further, omega-3 fatty acids can increase parasympathetic tone leading to an increase in heart rate variability and thus, protect the myocardium against ventricular arrhythmias (15). Increase parasympathetic tone and acetylcholine, the principle vagal neurotransmitter; significantly attenuate the release of TNK, IL-1, IL-6 and IL-18. Exercise enhances parasympathetic tone, and the production of anti-inflammatory cytokine IL-10 which may explain the beneficial action of exercise in the prevention of cardiovascular diseases and diabetes mellitus (15). TNF has neurotoxic actions, where as omega-3 fatty acids are potent neuroprotectors and brain is rich in these fatty acids. Based on this, it is suggested that the principal mechanism of cardioprotective and neuroprotective actions of omega-3 fatty acids can be due to the suppression of TNF and IL synthesis and release, modulation of hypothalamic-pituitary-adrenal anti-inflammatory responses, and an increase in acetylcholine release, the vagal neurotransmitter. Thus, there appears to be a close interaction between the central nervous system, endocrine organs, cytokines, exercise, and dietary omega-3 fatty acids (15).

Adding Omega-3 Fatty Acids to your Diet

The body can't easily manufacture omega-3s so they are best supplied by our food. Luckily, the one organism that can make omega-3s is plankton, which is eaten by certain types of fish. We can eat these fish and so get the omega-3 the plankton made originally (6).

One of the best food sources of omega-3 fatty acids is fresh fish, particularly salmon, mackerel, and herring. Try eating fish two to three times per week. Meat also provides both omega-3 and omega-6 fats. But meat delivers a large amount of saturated fat that can overwhelm the two essential fats. True, even for the leanest cuts (3).

The following foods are especially rich in the omega-3s:

- Algae
- Beans
- Chia
- Flaxseed, freshly ground
- Flax seed oil
- Fish oil
- Whole grains, such as brown rice and whole grain breads
- Kukui
- Purslane
- Tofu
- Walnuts
- Leafy vegetables
- Olive oil (3)

Also, cutting down on processed, fried, and fast foods, while healthful for a variety of reasons, will also help you achieve an appropriate ratio of omega-6 fatty acids to omega-3s, because these foods contain omega-6s. Also limit consumption of animal

fat, margarine, and anything with the words "hydrogenated" or "partially hydrogenated" on the label (4).

Flaxseed Supplementation

Flaxseed has recently gained attention in the area of cardiovascular disease primarily because it is the richest known source of both alpha-linolenic acid (ALA) and the phytosestrogen, lignans, as well as being a good source of soluble fiber (20). Human studies have shown that flaxseed can modestly reduce serum total and low-density lipoprotein cholesterol concentrations, reduce postprandial glucose absorption, decrease some markers of inflammation, and raise serum levels of the omega-3 fatty acids, ALA and eicosapentaenoic acid (20).

Atherosclerotic cardiovascular disease (ASCVD) is the leading cause of mortality in the United States. Flaxseed is a food that has recently gained attention in the area of ASCVD prevention because it contains three key constituents: alpha-linolenic acid (ANA), soluble fiber, and lignans (21). The American Heart Association cites flaxseed as a useful food to improve cardiovascular risk factors primarily by improving lipid profiles; however, various components of the flaxseed have been shown to have antioxidant, anti-inflammatory, antiplatelet, hypoglycemic, and blood pressure lowering properties (21).

Flax is a blue flowering crop that produces small, flat seeds that range in color from golden yellow to reddish brown. Flaxseed is commonly found as a whole seed, ground seed, or flaxseed oil. Flaxseed oil differs from the whole and ground flaxseed by being devoid of both fiber and lignans (20). Whole flaxseed contains 41% fat, 28% dietary fiber, 21% protein, and minerals, vitamins, and carbohydrates. The oil in flaxseed

is unique in that it is composed of 73% polyunsaturated fatty acids (PUFA), 18% monounsaturated fatty acids (MUFA), and 9% saturated fatty acids (22). This makes it a low saturated fat food. Flaxseed oil is the richest known source of the omega-3 fatty acid, ALA, which comprises approximately 55% of the total fatty acids. Table 1 lists those foods that naturally contain high levels of ALA. The percent of fats as ALA in flaxseed is 5.5 times higher than that in the next-highest sources (20).

TABLE 1: Principle Food Sources of alpha-Linolenic Acid (ALA) (20)

Food	Percent of Fatty Acid Composition as ALA
Flaxseed	55%
Canola oil	10%
Walnuts	10%
Soybean	7%
Lard	1%

ALA may prevent ASCVD through several mechanisms, including decreased inflammatory response, inhibition of platelet aggregation and thrombosis, decreased blood pressure, improved serum lipids, and prevention of cardiac arrhythmias (23). Extensive basic research on ALA and other omega-3 fatty acids suggests that they may protect against cardiovascular disease by interfering with production of proinflammatory and proaggragatory eicosanoids (prostaglandin E2, thromboxane Ax2, and leukotriene B4). Both ALA and linoleic acid (LA, omega-6) are essential fatty acids and therefore must be acquired through diet (23). Once consumed, LA and ALA can be converted to

different fatty acids that yield different classes of eicosanoids, which have different effects on inflammation, platelet aggregation, and vasoconstriction. LA can be converted to arachidonic acid (AA) through a series of alternating desaturation and elongation steps. By the same method, ALA can be converted to eicosapaenoic acid (EPA) and docosahexaenoic acid (DHA), the fatty acids primarily found in cold-water marine fish (23). The metabolism of omega-6 and omega-3 fatty acids requires the same desaturation enzymes and thus the two are in competition. Because human cannot interconvert omega-3 and omega-6 fatty acids, an excess of one class of PUFA can lead to the production of specific eicosanoids. Eicosanoids produced by EPA and DHA are involved with decreasing platelet aggregation, vasoconstriction, and thrombosis, whereas eicosanoids from AA produce the opposite effects (24). Increasing dietary ALA, EPA, and DHA can reduce the ratio of omega-6 to omega-3 and thus enhance the biosynthesis of eicosanoids that are less inflammatory. Flaxseed oil has been shown to increase EPA levels in plasma phospholipids (25).

Several observational studies have found a positive association between ALA and primary and secondary prevention of ASCVD (26,27). In the Nurses' Health Study, Hu et al. found a dose-relationship between ALA intake and risk of ischemic heart disease, with a 45% reduction in risk of those consuming the highest levels of ANA. However, some results from observational studies conflict with these positive findings even though, several secondary prevention trials involving ALA-enriched diets and supplemental ALA have implicated ALA as a cardioprotective nutrient (27).

The following sections describe data from human studies that address the effects of flax on various areas of cardiovascular risk, including lipids, inflammation, platelet aggregation, blood pressure, and glucose metabolism.

The bulk of the evidence suggests that whole flaxseed can modestly reduce total cholesterol and LDL by 1.6 to 18% in both hypercholesterolemic and normocholesterolemic patients without significant effect on HDL or triglycerides (TG) (28,29). Arjmandi et al. conducted a double-blind, randomized, crossover trial to compare the lipid effects of whole flaxseed with sunflower seed (control) in 38 moderately hyperlipidemic postmenopausal women. Researchers found a 14.7% reduction in LDL in the flax-treated group compared with the sunflower control period. There were no effects on TG or HDL, but lipoprotein, a novel marker of coronary heart disease, was mildly but consistently reduced by 7.4% (28).

Because it is widely recognized that atherosclerosis is an inflammatory disorder, there has been much interest in the effects of n-3 fatty acids on markers of inflammation. Most of the available data is on the effects of EPA and DHA from fish oils rather than on those of the precursor, ALA (30). Caughey et al. investigated the effects of a flaxseed oil-based diet on tumor necrosis factor (TNF) and interleukin-1B synthesis in healthy subjects. After incorporation of approximately 14 g ALA from flaxseed oil into the diet for 4 weeks, TNF and IL-1B production decreased by approximately 30% by lipopolysaccharide (LPS) – stimulated mononuclear cells (31). Another study found that 2g of ALA from flaxseed oil did not change circulating cytokine levels or numbers of inflammatory cells in healthy adults. There was however, a reduction in soluble vascular cell adhesion molecule 1 and soluble E-selectin, both of which are markers of endothelial

activation, in the flaxseed oil treated group (25). Allman et al. reported that 40 g of flaxseed oil over 23 days produced an increase in the platelet EPA:AA ratio (a marker for thromboxane production and platelet aggregation potential), which suggests that flaxseed oil may decrease the tendency of platelets to aggregate (32).

Two observational studies in more than 500 patients suggest that dietary and tissue ALA correlate with lowered blood pressure (33,34). In one study, a regression analysis found that for each 1% increase in tissue ALA, mean arterial blood pressure decreased by 5 mm Hg (34). Another observational study by Kestin et al. compared 9.2 g of ALA from flaxseed oil with 3.4 g of EPA and DHA from fish oil in 39 normotensive adults (35). At the end of the 6 weeks, only the fish oil-supplemented diet lowered systolic blood pressure by 5 mm Hg. Finally, a small clinical trial in 15 obese patients found that 20 g/day of ALA from flaxseed oil had no effect on blood pressure, but did increase systemic arterial compliance (a measure of endothelial function) compared with an oleic acid-enriched diet (36).

Data from two clinical trials suggest flaxseed may improve glucose homeostasis. In the first two experiments by Cunnane et al., six volunteers consumed 50 g of carbohydrates from bread made with either flaxseed or wheat flour. Blood glucose samples were obtained at baseline and 15, 30, 45, and 60 minutes after starting to consume the meal. The authors found a 28% reduction in the area under the curve for serum glucose in those consuming flax compared with those consuming wheat (37). In a separate experiment, soluble fiber extracted from flaxseed reduced glucose absorption by 27%. Lemay et al. found 40 g ground flaxseed added to the diet of postmenopausal women for 2 months significantly reduced blood glucose from baseline (38).

Conclusion

Current literature emphasizes a practical dietary approach to help balance out the omega-6 fatty acids with the omega-3 fatty acids. Our ancestors lived with a daily ratio of the two fatty acids as 1:1. Today's society is faster paced, so people select fast foods or convenient foods that are loaded with omega-6 fatty acids. Research shows that today the average person consumes a ratio of anywhere from 100:1 to 25:1 ratio of omega-6 fatty acids to omega-3 fatty acids. According to research the omega-6 fatty acids overpower the omega-3 fatty acids and make them inactive. This is leading to several different health problems including: childhood asthma, depression, obesity, skin problems, heart disease, migraines, inflammatory diseases, arthritis, etc...

According to research the consumption of omega-3 fatty acids into the daily diet can help decrease the above problems or even eliminate them. Omega-3 fatty acids can be consumed as food (fish, beans, walnuts, leafy vegetables) or as a supplement. Several supplements are available today, whether it is oral capsules, flaxseed oil, flaxseed, or enriched foods. Everyday it is becoming more readily available.

A lack of awareness and education of our society has lead to this extreme problem with our diet. Also the fast paced lifestyle everyone lives today also has an impact. An effort has to be made to consume omega-3 fatty acids, so Americans are going without. If society would be educated on what essential omega-3 fatty acids are and how much we put our health at risk by being deficient in them, maybe then the average diet would improve.

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