University of Nevada, Reno

Omega 3 Fatty Acid Recommendations in the American Diet

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of the requirements for the degree of

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by

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Abstract

With cancer as the second leading disease killer in the United States, this review aimed to investigate the effect of omega 3 fatty acids on cancer risk and tumor growth as well as evaluate American’s intake of two kinds of omega 3 fatty acids known as docosahexaenoic acid and eicosapentaenoic acid. The review first goes into the impact of lifestyle and living environment, such as diet, on cancer. The review then looks at the impact of both high or low total dietary fat consumption, and the two diet’s effects on cancer risk and tumor growth. An overview of fatty acids and their impact on their body are then explained along with the function and importance of omega 3 and omega 6 fatty acids. The benefits of omega 3 fatty acids are then examined in relation to cancer. Finally intake of omega 3 fatty acids through food and an evaluation of current intake in America is compared to recommendations by the 2015-2020 Dietary Guidelines, Academy of Nutrition and Dietetics, and American Heart Association.
Acknowledgements

I would like to thank Dr. Ron Pardini and Dr. Shavawn Forester for all of the help they’ve given me this past year. Dr. Valentine for being understanding throughout all the bumps in the road. I’d also like to thank the honors program for giving me the opportunity to work on a thesis and experience the process. Caffeine for helping me a lot in my undergrad career but mostly because it was one of the things that allowed me to push through the year. Lastly, thank you to my family and my friends for all of the support that they’ve given me throughout the years and especially this past year.
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<th>Abbreviation</th>
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<tr>
<td>Adequate Intake</td>
<td>AI</td>
</tr>
<tr>
<td>Arachidonic Acid</td>
<td>ARA</td>
</tr>
<tr>
<td>Cyclooxygenase</td>
<td>COX</td>
</tr>
<tr>
<td>Docosahexaenoic Acid</td>
<td>DHA</td>
</tr>
<tr>
<td>Dietary Reference Intake</td>
<td>DRI</td>
</tr>
<tr>
<td>Eicosapentaenoic Acid</td>
<td>EPA</td>
</tr>
<tr>
<td>Fatty Acid</td>
<td>FA</td>
</tr>
<tr>
<td>Gram</td>
<td>g</td>
</tr>
<tr>
<td>Institute of Medicine</td>
<td>IOM</td>
</tr>
<tr>
<td>Milligram</td>
<td>Mg</td>
</tr>
<tr>
<td>Omega 3 Fatty Acid</td>
<td>N3FA</td>
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<tr>
<td>Omega 6 Fatty Acid</td>
<td>N6FA</td>
</tr>
<tr>
<td>Prostaglandin E2</td>
<td>PGE2</td>
</tr>
<tr>
<td>Recommended Daily Allowance</td>
<td>RDA</td>
</tr>
<tr>
<td>United States</td>
<td>US</td>
</tr>
<tr>
<td>United States Department of Agriculture</td>
<td>USDA</td>
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</table>
Introduction

Every five years the United States Department of Agriculture’s (USDA) Center for Nutrition Policy and Promotion releases a report called Dietary Guidelines for Americans with the most current version created for 2015-2020. The guidelines consist of recommendations for nutrient intake and diets for the American public, and is based off current medical knowledge. The dietary recommendations are meant to guide Americans to a healthier lifestyle but Americans don’t always follow the guidelines. In 2008, only “3 out of 100 US adults, follow all the recommendations to consume 5 fruits and vegetables daily, get regular physical activity, maintain a healthy weight, and not smoke” (Bier et al., 2008)

The diet in the United States is heavy in red meat and low in vegetables. From 2007 – 2010, the U.S. population did not meet fruit and vegetable recommendations and consumed about less than 1 cup and 1.5 cups per day of fruits and vegetables respectively (Moore & Thompson, 2015). In contrast, in 2015 the United States consumed about 109.4 lbs. of red meat and only 15.5 lbs. of commercial fish and shellfish (United States Department of Agriculture Economic Research Service, 2017). The high amount of meat consumed, the way foods are cooked in oil, and a low intake of vegetables is linked to a high fat diet correlated with obesity and cancer (Rouhani, Salehi-Abargouei, Surkan, & Azadbakht, 2014). However, consumption of fruits, vegetables, and meat alone are not sufficient enough to determine the nutritional diet quality of the U.S. associated with overall health. Specific nutrients such as vitamins or fatty acids found in meats, fruits, and vegetables need to be further evaluated to determine the association between food
and cancer. Two components of dietary fat associated with cancer are omega 3 fatty acids (N3FA) and omega 6 fatty acids (N6FAs).

In disease free body states, omega 3 fatty acids are essential to the body’s normal function because they are incorporated into the cell membranes of our body, and play an important role in cell signaling, a process that controls cell proliferation. Due to their importance in the body, N3FAs have been studied relating to areas of health including cancer. For example, research on N3FA levels in the body have indicated that high levels of N3FAs are inversely associated with risk of breast cancer (Kim et al., 2009; Zheng, Hu, Zhao, Yang, & Li, 2013). The main sources of N3FAs for humans come from plants such as chia seeds, flaxseed oil, and fatty fish like salmon. However with the American diet heavily focused on meat consumption and less on fruits, vegetables, and fish intake, low levels of dietary N3FAs and high levels of N6FAs accumulate in the body and can promote cancer. A high ratio of N6FAs compared to N3FAs in the diet can lead to cancer due to increased inflammation in the body (Godsland, North, & Johnston, 2011). This review proposes to investigate the intake of N3FAs in the American diet compared to the recommended intake levels by the 2015-2020 Dietary Guidelines, Academy of Nutrition and Dietetics, and American Heart Association because of the impact N3FAs have on health and cancer. Once the level of intake in the American diet has been determined, the investigation will expand to the feasibility to meet N3FA recommendation levels from foods alone (no supplements), with a focus on the ability of the average American to afford it.

It is important to investigate the topic of N3FAs in the diet because even though dietary recommendations can be created; it’s important to evaluate the American
population’s ability to attain the recommendations. If Americans are unable to achieve N3FA recommendations, then it becomes a public health concern because deficiencies can lead to health problems such as an increased risk for cancer. The reasons why the recommendation isn’t acquired then needs to resolved. For example, if recommendations aren’t met because prices are too high for fatty fish, then cheaper ways to incorporate N3FAs into the diet will be needed. If Americans are able to afford N3FA recommendations, then food needs to be fortified with N3FAs.

**Cancer in the United States**

In 2018, it is estimated that there will be 609,640 total deaths or about 1,670 deaths per day due to cancer in the United States (Siegel, Miller, & Jemal, 2018). Cancer is the second leading cause of death in the United states and 19% of newly diagnosed cancers in 2018 are preventable as they are associated to lifestyles that include smoking, obesity, excessive alcohol consumption, physical inactivity, and diet (Siegel et al., 2018). Nutrition related environmental factors such as diet and body weight play a big role in cancer with 40% of cancers in the United States related to obesity (Centers for Disease Control And Prevention, 2017).

Lifestyle and living environment of the United States plays an important role in the incidence of cancer as shown by an increase in breast cancer risk through the generations of immigrant Asian-American women after moving to the U.S. (Ziegler et al., 1993). An increase in colon cancer risk to levels of equal risk seen in American Caucasian women was seen in Japanese immigrants who moved to Hawaii and was attributed to a change in their diet (Maskarinec & Noh, 2004). The impact of diet on the
incidence of cancer shows that food choices can have an influence on the incidence and possible treatment of cancer.

**High Fat Versus Low Fat Diets and Cancer**

Dietary fat has been associated with cancer incidence and mortality, therefore altering dietary fat consumption could lower the risk of acquiring cancer and mortality associated with cancer (Reddy, Watanabe, & Weisburger, 1977). Diets high in fat compared to diets low in fat were first studied to show that a high fat diet promoted cancer formation (Reddy et al., 1977). However, it was soon found that high fat diets, such as those eaten by Eskimos of Greenland and Alaska, could be responsible for the opposite effect and decrease cancer formation (Rose, 1997; Carroll, Braden, Bell, & Kalamegham, 1986).

The answer to this anomaly was in the ratio of types of fat consumed by the subjects (Kato et al., 2002). In experiments exploring the impact of dietary fats on experimental diets for mice, varying amounts of corn oil, menhaden oil, and golden algae oil were given up to 24% fat in the diet and compared to a diet of just corn oil at 24% (Kato et al., 2002). The different types of oil represented two main types of fatty acids found in foods known as N6FAs and N3FAs (Kato et al., 2002). The corn oil was used to represent a diet high in N6FAs, the menhaden oil was used to represent a mixture of N3FAs, and the golden algae oil was used to represent a specific N3FA known as docosahexaenoic acid (DHA) (Kato et al., 2002). The results of the study showed that mice given the ratio of 8% corn oil and 16% menhaden as well as 8% corn oil and 16% golden algae oil had a significant decrease in tumor growth rate compared to the diets of
24% corn oil and 8% corn oil (Kato et al., 2002). These results showed that the type of fat was important, as the same percentages of dietary fat resulted in a different impact on colon tumor progression. Therefore the type of fat was more important in controlling tumorigenesis than the level of fat in the diet.

**Fatty Acids**

The research done by Kato et al. (2002) showed that different types of fats or lipids which are comprised of fatty acids can influence the growth of a cancerous tumor. A lipid is the scientific term for a fat. As seen in Figure 1, a fatty acid is classified as a lipid because of its structure with an acidic head designated as the alpha carbon and long carbon chain, known as a hydrocarbon chain, and the end of the carbon chain designated the methyl or omega end.

![Figure 1. The General Structure of a Fatty Acid Broken Down into Individual Components](image)

As seen in Figure 2, phospholipids are comprised of fatty acids, a glycerol base, phosphate, and either choline, serine, or ethanolamine.
Phospholipids are components of cell membranes and signaling messengers that are used throughout the body in response to various stimuli (Röhrig & Schulze, 2016). Fatty acids can also be converted and stored in the body as triglycerides for later use when large amounts of energy is needed (Röhrig & Schulze, 2016).

The large amount of energy that fatty acids provide can also be used to help cancer tumors proliferate (Currie, Schulze, Zechner, Walther, & Farese, 2013). In cancer, fatty acid metabolism and synthesis by the tumor cells is upregulated because fatty acids provide the energy, building blocks for cell membranes, and signaling molecules needed for the tumor to grow (Currie et al., 2013; Santos & Schulze, 2012). The type of fatty acid used by the body and the tumor can affect the level of inflammation within the body, which can promote cancer growth (Calder, 2006). The two main kinds of fatty acids that have been the focus of cancer research are the N6FAs and N3FAs because they are involved in intra-cellular signaling processes in the body, such as inflammation, that can...
affect the tumor proliferation (Calder, 2006; Innis, 2014; Tvrzicka, Kremmyda, Stankova, & Zak, 2011). The structures of an N3FA and N6FA is shown in Figure 3.

![Chemical Structures of an N3FA and N6FA](image)

*Figure 3. Chemical Structures of an N3FA and N6FA.*

**Omega 3 Fatty Acid and Omega 6 Fatty Acid Importance to the Body**

The primary way to get N3FAs and N6FAs into the body is to eat it because the body can’t synthesize the N3FA alpha-linolenic acid (ALA) and the N6FA linoleic acid (LA), therefore they are essential nutrients. These two fatty acids are the precursors to a family of N3FAs and N6FAs that are then synthesized in small amounts in the liver as seen in Figure 4 (Flock, Harris, & Kris-Etherton, 2013).
Figure 4. Food Sources of the Essential Omega 6 Fatty Acid Linoleic Acid and Essential Omega 3 Fatty Acid Alpha-Linolenic Acid. Fatty Acid Synthesis From the Essential Fatty Acids and the Enzymes That Transform Them to Inflammatory Cytokines. (Haag, 2002)

The two main long chained N3FAs involved in general human health are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which are synthesized from ALA (Gogus & Smith, 2010; Tvrzicka et al., 2011). However, the conversion of ALA to DHA is slow and doesn’t meet the body’s needs (Kris-Etherton, Greiger, & Etherton, 2009). Therefore the consumption of DHA becomes very important.

N3FAs are important to the body for neural development and growth in the brain because infant brains require DHA, arachidonic acid (ARA), and EPA to create neuronal membranes (Janssen & Kiliaan, 2014). As adults, N3FAs are still needed for neural
functioning but they also play a role in the health and maintenance of the eyes (Molina-Leyva, Molina-Leyva, & Bueno-Cavanillas, 2017).

Although, these are all important functions in the body, one of the main focus points of N3FAs and N6FAs related to cancer initiation and progression is inflammation. N3FAs have an anti-inflammatory effect and N6FAs have a pro-inflammatory effect (Weylandt et al., 2015). EPA and ALA do this by competing with the N6FA arachidonic acid and alpha linolenic acid as a substrate to the cyclooxygenase (COX)-2 inflammatory pathway in the body and for incorporation into cell membrane phospholipids. (Calder, 2006; Roy et al., 2015). In the COX-2 pathway, N6FAs produce and release pro-inflammatory cytokines such as prostaglandin E2 (PGE2) and anti-inflammatory cytokines are produced and released from N3FAs (Bagga, Wang, Farias-Eisner, Glaspy, & Reddy, 2003). Therefore, a higher ratio of N3FAs to N6FAs, produces more anti-inflammatory mediators in the body outcompeting the pro-inflammatory N6FAs.

Although, inflammation is part of the body’s normal response to problems, long lasting and uncontrolled inflammation can lead to disease states such as cancer (Calder, 2006; Godsland et al., 2011).

**Omega 3 Fatty Acids and Cancer**

A meta-analysis of N3FAs effects on various types of cancer has shown that dietary omega-3 fatty acids taken alone have had inconsistent effects on breast, lung, colorectal, bladder, and prostate cancer (Berquin, Edwards, & Chen, 2008; Brasky et al., 2013; MacLean et al., 2006). However, past research into N3FAs effects on cancer have been linked to a reduction in colorectal, breast, lung, and prostate cancer growth (Berquin
et al., 2008; Pardini, 2006). Whereas an increased omega 6 to omega 3 ratio has been found to increase the incidence of prostate and breast cancer (Kang & Liu, 2013; Williams et al., 2011).

One connection between omega 3 and omega 6 fatty acids showed that N3FAs had an anti-cancer effect in the body, but N6FAs promoted cancer through mechanisms such as angiogenesis (Kang & Liu, 2013). Angiogenesis is the creation of new blood vessels in the body, which benefits a tumor because the blood vessels bring in the nutrients the tumor needs to grow. In addition, a case study report on the intake of omega-3 fatty acids showed a possible decrease or stagnation in tumor growth in a lung cancer patient with malignant fibrous histiocytoma without chemotherapy treatment (Pardini, Wilson, Schiff, Bajo, & Pierce, 2005).

More recent studies have supported the anti-cancer effects of omega 3 FAs (Cavazos, Price, Apte, & deGraffenried, 2011; Shin et al., 2013; Yang, Zhu, Lin, Song, & He, 2017). In a case report on the lungs, a patient’s tumor shrank after taking 17.2g of N3FAs a day (Pardini et al., 2005). In a meta-analysis of breast cancer studies with dietary omega 3 intake, the dietary intake of N3FAs was associated with a lower incidence of breast cancer (Zheng et al., 2013). In a treatment of breast cancer cell lines with N3FAs and vitamin D, all three cancer cell lines showed a reduction in cell growth when treated with EPA or DHA and vitamin D (Yang et al., 2017). The omega 3 fatty acids were shown to be incorporated into the phospholipids of breast cancer cell lines, which led to a decrease in cell growth (Corsetto et al., 2012; Siddiqui et al., 2011).

In a 22 year study, fish or omega 3 supplement consumption was also associated with a lower risk of colorectal cancer (Hall, Chavarro, Lee, Willett, & Ma, 2008). In
colorectal cancer treatment, chemoresistant colorectal cancer cells were shown to have decreased cholesterol levels associated with EPA and DHA treatment, which then led the cells to become sensitized to chemotherapy treatment. The decreased cholesterol synthesis and sensitization of cells to chemotherapy treatment is important because the same mechanism potentially can be applied to other cancers such as prostate cancer.

**Omega 3 Fatty Acid Recommendations**

The recommendation established by the Food and Nutrition Board of the Institute of Medicine (IOM) establishes Dietary Reference Intakes (DRI) for nutrients based on reviews of research (National Institutes of Health Office of Dietary Supplements, 2018). The Recommended Dietary Allowance (RDA) is used to set average daily intakes in order to meet the body’s nutritional requirements for optimal health. The Adequate Intake (AI) is used when there is not enough research to develop an RDA but there is still an assumed level of intake that is needed to avoid nutritional deficiency. For N3FAs an AI of 1.6 grams of ALA for males and 1.1 grams for females per day was set (National Institutes of Health Office of Dietary Supplements, 2018). A DRI exists for ALA because the body cannot make it on its own. However, there is currently no DRI from the IOM for EPA and DHA because there is not enough evidence to create one yet, but the possible benefits of EPA and DHA have led to recommendations by various groups across the U.S. The general recommendation is to have at least two servings, or 200 grams, of fish per week which can be equivalent to about 250-500 mg of N3FAs per day as shown by recommendations of various organizations in Table 1.
The differences in the recommendations from the different organizations can be attributed to how fast the organization can review the current research. For example, the 2015-2020 Dietary Guidelines for Americans is released every 5 years with recommendations on macronutrient intake, such as carbohydrates, fat, and protein, and micronutrients such as vitamins and minerals (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015). The Academy of Nutrition and Dietetics releases their position on nutrients, such as N3FAs, in journal articles which could also take years to publish (Vannice & Rasmussen, 2014). Finally, the American Heart Association posts their recommendations online to the public which can be easily updated (American Heart Association, 2016).

Table 1. Omega 3 Fatty Acid Intake Recommendations by Organizations in the United States. (American Heart Association, 2016; U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015; Vannice & Rasmussen, 2014)

<table>
<thead>
<tr>
<th>Organization or Agency</th>
<th>Population</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-2020 Dietary Guidelines for Americans Created by the Health and Human Services and USDA</td>
<td>Adults</td>
<td>8 ounces per week of a variety of seafood, averages to 250 mg DHA + EPA/ day</td>
</tr>
<tr>
<td>Academy of Nutrition and Dietetics</td>
<td>Adults</td>
<td>Fatty fish 2x per week averages to 500 mg EPA + DHA/ day</td>
</tr>
<tr>
<td>American Heart Association</td>
<td>Adults</td>
<td>Eat fish (particularly fatty fish) 2 servings (200 g) per week with no specific average per day specified</td>
</tr>
</tbody>
</table>
**Nutrition and Omega 3 Fatty acids**

People can incorporate N3FAs into the diet through a variety of foods. ALAs can be primarily found in plants such as chia seeds, walnuts, flaxseed oil, and edamame (United States Department of Agriculture National Nutrient Database for Standard Reference, 2018). EPA and DHA are primarily found in fatty fish such as salmon, mackerel, and halibut (United States Department of Agriculture National Nutrient Database for Standard Reference, 2018). The diet of American males and females from 2013-2014 had a mean total of 100 milligrams (mg) of EPA and DHA and a mean total of 1.82 grams of ALA per week (U.S. Department of Agriculture et al., 2017).

A closer look at the average American diet shows an emphasis on red meat and not seafood, which are important sources of long chained N3FAs. In 2015, the Americans consumed about 109.4 lbs. of red meat compared to 15.5 lbs. of commercial fish and shellfish, and has consistently consumed more beef, pork, chicken, and turkey over fish and shellfish as shown by Figure A1 in the appendix (United States Department of Agriculture Economic Research Service, 2017). Figure 5 shows, seafood and fish was the least consumed protein per week in 2014 at 2.7 ounce equivalents.
Figure 5. Various Sources of Total Protein Consumption in the United States in 2014 on a Per Week Basis. All Sections Represent A Type of Food or Similar Foods That Contribute To Total Protein Consumption (Kantor, 2016).

Of the fish consumed in the United States, shrimp, salmon, canned tuna, pollock, and tilapia were consistently the top five fish consumed from 2007 to 2015 as seen in Table A1 in the appendix. A lack of seafood in the diet limits the intake of EPA and DHA which are the essential key nutrients that have been shown to be beneficial in humans (Kris-Etherton et al., 2009).

With the American intake recommendations in mind, a week’s worth of EPA and DHA would be 1,750 milligrams by the 2015-2020 Dietary Guidelines and 3,500 milligrams by the Academy of Nutrition and Dietetics (U.S. Department of Health and Human Services & U.S. Department of Agriculture, 2015; Vannice & Rasmussen, 2014). Therefore the previously stated combined intake of DHA plus EPA of males and females at 100 mg per day or 700 mg per week during 2013-2014 does not meet any of the
recommendations. Table 2 shows that of the top five fish consumed in the United States, only tuna and salmon have a high DHA and EPA content. With 100 grams equivalent to about one serving, 200 g of shrimp, pollock, and tilapia is not enough to meet a week’s worth of DHA and EPA recommendations. However, 200 g servings of salmon and tuna would meet recommendations.

Table 2. Top Five Fish Eaten in the United States from 2007-2015 with Nutrition Database Numbers (NDBNO) and the grams of DHA, EPA, and ALA per 100 grams of Fish (United States Department of Agriculture National Nutrient Database for Standard Reference, 2018)

<table>
<thead>
<tr>
<th>NDB_NO</th>
<th>Description</th>
<th>DHA (g) Per 100 g</th>
<th>EPA (g) Per 100 g</th>
<th>ALA (g) Per 100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1527</td>
<td>Crustaceans, shrimp, cooked</td>
<td>0.015</td>
<td>--</td>
<td>0.001</td>
</tr>
<tr>
<td>1523</td>
<td>Fish, salmon, Atlantic, farmed, cooked, dry heat</td>
<td>1.457</td>
<td>0.69</td>
<td>--</td>
</tr>
<tr>
<td>1520</td>
<td>Fish, salmon, Atlantic, wild, cooked, dry heat</td>
<td>1.429</td>
<td>0.411</td>
<td>--</td>
</tr>
<tr>
<td>1512</td>
<td>Fish, tuna, white, canned in oil, drained solids</td>
<td>0.178</td>
<td>0.066</td>
<td>--</td>
</tr>
<tr>
<td>1512</td>
<td>Fish, tuna, white, canned in water, drained solids</td>
<td>0.629</td>
<td>0.233</td>
<td>--</td>
</tr>
<tr>
<td>1518</td>
<td>Fish, tuna, white, canned in water, without salt, drained solids</td>
<td>0.629</td>
<td>0.233</td>
<td>--</td>
</tr>
<tr>
<td>1526</td>
<td>Fish, tilapia, cooked, dry heat</td>
<td>0.13</td>
<td>0.005</td>
<td>0.045</td>
</tr>
<tr>
<td>1526</td>
<td>Fish, pollock, Alaska, cooked</td>
<td>0.227</td>
<td>0.104</td>
<td>--</td>
</tr>
<tr>
<td>1506</td>
<td>Fish, pollock, Alaska, cooked, dry heat (may contain additives to retain moisture)</td>
<td>0.423</td>
<td>0.086</td>
<td>--</td>
</tr>
</tbody>
</table>
Feasibility of Meeting Omega 3 FA Requirements through Diet Alone in the U.S.

Since Americans are not achieving the recommended intake of DHA and EPA, the question is then if they are able to meet it by only eating the food that is preferred as shown by the top five fish (U.S. Department of Agriculture et al., 2017). To achieve 1,750 mg of EPA and DHA per week, a person would have to eat 1160 g of shrimp, 100 g of salmon, 200 g of tuna, 500 g of tilapia, and 500 g of pollock per week, if they were to stick to only one type of fish, to achieve the lowest recommendations set by the 2015-2020 Dietary Guidelines. A different combination of fish may not even satisfy the recommendation because 100 g of tuna would still need multiple servings of the different types of fish if salmon was excluded. On the other hand, one serving of salmon would achieve the Dietary Guidelines.

The monetary price of achieving these guidelines could be feasible with Table 3 showing the price per pound of each fish. The price per pound was used because fish and seafood are usually sold by the pound. Since seafood prices can vary depending on location, prices for seafood that are available to be shipped across the U.S. was used to control for variability.

Table 3. Prices Per Pound in US Dollars of The Top 5 Fish Eaten in America
("Fisherman’s Cove Seafood," 2018)

<table>
<thead>
<tr>
<th>Fish</th>
<th>Price Per Pound (US Dollar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrimp</td>
<td>3.59</td>
</tr>
<tr>
<td>Salmon</td>
<td>14.99</td>
</tr>
<tr>
<td>Canned Tuna</td>
<td>5.28</td>
</tr>
<tr>
<td>Tilapia</td>
<td>4.99</td>
</tr>
<tr>
<td>Alaskan Pollock</td>
<td>6.50</td>
</tr>
</tbody>
</table>
With about 4.5 g of fish per pound, achieving N3FA recommendations with the fish containing the highest amount of N3FA, salmon, would cost about $3.33 per week. One pound of canned tuna and one pound of tilapia would cost about $10.30, but a person would have to eat 700 g of fish to reach N3FA recommendations. To translate the prices into possible affordability of food for an average American the median wages of males and females in America was used. The median wage of an American male is about $941 and $770 for a female per week (Bureau of Labor Statistics, 2018). Therefore the average American should be able to afford and achieve N3FA recommended intakes because one pound of fish could be used to meet N3FA recommendations for several weeks.

However, food preference is an issue as not everyone likes salmon or fish in general and in order to meet the recommendations, a person would have to eat more servings of fish when fish with lower N3FA content is eaten. Therefore, Americans inability to achieve N3FA recommendations can’t be attributed to the affordability of food because they are able to achieve it when the right fish is eaten.

**Discussion and Conclusions**

Omega 3 fatty acids are beneficial to the health of humans to prevent chronic inflammation and disease states, such as cancer and cardiovascular disease, that can be linked to it. However, Americans are still only consuming 100 mg of EPA and DHA per week, which is not enough to achieve the lowest recommended intake of EPA and DHA per week. The price of food sources containing EPA and DHA is also affordable to the average American male and female. However, a look back at the average American diet shows an emphasis on red meat and less seafood. Of the top 5 seafood eaten in America,
only salmon and tuna are considered fatty fish and can achieve recommendations in one or two servings. The other fish would need to be eaten in higher quantities to achieve the same levels of DHA and EPA intake.

To incorporate more DHA and EPA into the body the eating patterns of Americans needs to shift away from heavy consumption of red meats and replace some meals with fatty fish. Further research should focus on changing diet patterns of red meat and fish in the United States or diet patterns on the type of fish eaten in the United States and why. Further research can also be done on N3FA supplementation and affordability patterns for supplements.
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Data: Nutrient Intakes from Food and Beverages by Gender and Age


https://doi.org/10.1155/2015/143109


Appendix A: USDA Food Availability

Figure A1. USDA Food Availability Data of Beef, Pork, Chicken, Turkey, Fish and Shellfish, and Veal and Lamb from 1970 to 2014 (United States Department of Agriculture Economic Research Service, 2017)
Appendix B: U.S. Fish Consumption from 2007 to 2015

Table A1. U.S Per Capita Consumption of Fish by Species in Pounds from 2007 to 2015

(National Fisheries Institute, 2016)

<table>
<thead>
<tr>
<th>Species</th>
<th>2015 lbs</th>
<th>Species</th>
<th>2014 lbs</th>
<th>Species</th>
<th>2013 lbs</th>
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<td>4.000</td>
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