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Nutrition and Vision: How Diet Influences Eye Disease — Learn the Relationship Between Nutrition and Vision, Key Nutrients for Disease Management, and Supplementation Recommendations

By Alexandria Hardy, RDN, LDN

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Eye disease is a broad category that includes many subsets, including age-related macular degeneration (AMD),[1] glaucoma, and cataracts. Age is the most significant risk factor for the development of eye disease. As the percentage of Americans reaching 65 and older increases and rates of eye diseases rise, there's a significant interest in identifying dietary factors that can help slow the development and progression of these conditions.

Some eye diseases such as glaucoma usually don't produce symptoms, so regular eye exams are the best form of preventive care.[2] Other types of eye disease such as AMD or cataracts may present symptoms, including pain, dimness of vision, double vision, flashes of light, or fluid leaking from the eye, each of which warrants a call or visit to the eye doctor.[3] Because eye disease typically is progressive and irreversible, preventing and delaying the onset of disease are of great interest to researchers.[4] Behaviors to modify risk factors are essential to prevention, the top three being smoking cessation, initiation of exercise, and nutrition/quality of diet. Of particular interest to researchers are the use of oral supplementation, antioxidant and micronutrient consumption, and dietary patterns in at-risk or diagnosed populations.

This continuing education course reviews the relationship between nutrition and vision with a focus on glaucoma and AMD. Key nutrients for disease management are identified, and supplementation recommendations are examined.

AMD

The National Eye Institute estimates that the number of Americans who will suffer from AMD will be 5.4 million by 2050.[1] This is more than double the 2010 rate of nearly 2.1 million, with the Hispanic population showing the greatest increase in number of cases.[1] Those at greatest risk of developing AMD are white Americans older than 80; the majority of those are women.[1] The risk of developing AMD increases with age, with nearly 14% of adults older than 80 affected.[1]

AMD is "the leading cause of irreversible visual impairment in developed countries, accounting for more than 50% of blindness in the United States."[5]

AMD is defined as a series of changes that occur in the fovea, within the macula in the two-diameter radius in the retina, and are classified in the following five stages: no aging changes, normal aging changes, early AMD, intermediate AMD, and late AMD. These stages address the presence or absence of drusen, pigmentation, and atrophy.[5] Drusen, yellow deposits made up of lipoproteins, don't cause AMD, but their appearance can cause hyper- or hypopigmentation and may increase risk of AMD developing. These variances in drusen size and pigmentation can cause geographic atrophy or choroidal neovascularization, the creation of new blood vessels in the eye.[5] The presence of both indicate late-stage AMD and significant vision loss.[5]

Clinical treatment exists for the more advanced form of the disease, but there are no approved interventions for the early and intermediate stages.[5] Late AMD can be treated with a combination of medication and supplementation,[4] but clinicians and researchers are interested in identifying preventive therapies to halt disease progression. When risk factors are assessed, smoking and obesity emerge as the main variables over which patients have control. Smoking cessation has a positive correlation with the development of late-stage (neovascular) AMD and should be the primary line of defense for preventing or halting progression.[6] Increased physical activity is encouraged for those at risk or currently diagnosed with AMD and has a dual purpose: to decrease both BMI and the risk of developing other obesity-related comorbidities.[6] These include but aren't limited to hypertension, type 2 diabetes, coronary heart disease, and hypercholesterolemia.[6]

There's no standard nutrition recommendation for primary prevention, but researchers theorize that the inclusion of omega-3 long-chain polyunsaturated fatty acids and foods low on the glycemic index (GI) may be beneficial, particularly if they replace saturated or trans fats and high-GI foods.[6]

Glaucoma

Glaucoma is an irreversible eye disease characterized by neuropathy.[7] Risk factors include age, ethnicity, family history, nearsighted vision, retinal detachment, previous high dose steroid usage, and prior eye surgery, tumors, and inflammation.[2] The only known modifiable risk factor is intraocular pressure, which can be influenced by a variety of environmental and lifestyle factors such as diet, exercise, smoking, and beverage consumption—particularly caffeine.[2,7] Like those with AMD, persons at risk of developing glaucoma are encouraged to exercise regularly, practice smoking cessation, and choose nutrient-dense foods. Foods of particular importance in slowing the development or progression of glaucoma include vibrantly colored produce and whole grains (both low-GI foods) and protein sources rich in omega-3 fatty acids.[2]

The incidence of glaucoma is similar to that of AMD, with age as a leading factor. Rates are projected to grow from 2.7 million in 2010 to 6.3 million in 2050.[8] Women are more prone to develop glaucoma, likely due to their longer life

expectancy. In 2010, 61% of the diagnosed glaucoma cases were women.[8] White Americans are at a higher risk than other races/ethnicities overall but black Americans have the highest risk factors after age 40.[8]

Cataracts

The development of cataracts begins at age 40 for many Americans, and the risk continues to increase with each decade of age.[9] The risk varies across different races/ethnic groups with 53% of black Americans, 61% of Hispanic Americans, and 70% of white Americans developing cataracts by age 80.[9] Women, again, are more likely to develop this type of eye disease, accounting for 61% of cataract cases.[9] Estimates predict that cataract cases will double to 50 million by 2050, with Hispanic Americans experiencing the highest increase in incidence.[9] Cataracts are one of the major causes of visual disability, and, according to research published in ***Ophthalmology*** in November 2012, cataract surgery is one of the most common procedures performed in the United States.

Age-Related Eye Disease Studies

The original Age-Related Eye Disease Study (AREDS) in 2001 showed that the progression of AMD slowed by nearly 25% when a specially formulated supplement was taken daily over a five-year period; however, the supplement had no effect on cataract patients.10-12 The supplement's aim was to protect central vision functionality, which is linked with reading, driving, face recognition, and other routine activities.[10,11] The original supplement contained 500 mg vitamin C, 400 IU vitamin E, 15 mg beta-carotene, 80 mg zinc oxide, and 2 mg copper.[12] A limitation of this supplement was the inclusion of beta-carotene, which when taken in supplemental form has been linked to lung cancer in current or former smokers, thus yielding it unsafe for some AMD patients.

A second nutrition supplement study, AREDS2, was formulated based on research generated from the follow-up of the original study in 2011. Researchers were curious as to whether the addition of antioxidants would help maintain retinal function. They also lowered the zinc content due to its association with stomach upset and replaced the type of carotenoid included after beta-carotene was linked to lung cancer.[10,11] The supplement used in AREDS2 included 500 mg vitamin C, 400 IU vitamin E, 10 mg lutein, 2 mg zeaxanthin, 80 mg zinc oxide, and 2 mg copper oxide. The study participants were divided into four subgroups, which included a control group (AREDS original formula), AREDS without beta-carotene, AREDS with low zinc (25 mg), and AREDS with no beta-carotene and low zinc. This fourth group used the supplement described for AREDS2. These supplements were taken daily for five years. Each subject also received one or more supplements including carotenoids, omega-3 fatty acids DHA and EPA, or a placebo. Two of the four subgroups benefited from the inclusion of these antioxidants, with advanced AMD reduced by 18% and 25% in subjects who received the lutein/zeaxanthin combination without beta-carotene and with low dietary antioxidant intake, respectively.[10,11] There was no significant impact from the additional fatty acid/carotenoid supplementation.[4]

An ophthalmologist may recommend the supplement used in AREDS2 for people at risk of developing AMD or for those with diagnosed AMD with the goal of slowing its progression.[10] Per the researchers, it's a safe and effective supplement for the entire AMD patient population.[10,11]

Key Nutrients for Disease Management

Nutrition can play a key role in slowing the progression of, or potentially preventing, AMD, glaucoma, and cataracts. The Carotenoids in Age-Related Eye Disease Study (CAREDS) used a food frequency questionnaire and a modified version of the 2005 Healthy Eating Index to illustrate that a healthful diet could decrease the risk of eye disease. The researchers defined a healthful diet as 3.5 servings of produce, 2.3 servings of dairy, 2.7 oz of a meat or vegetarian protein source, and 3.5 servings of grains (including one whole grain) per day.[6] Women whose diets scored highest were 46% less likely to develop AMD.[6]

Antioxidants

The focus on antioxidants is largely based on the idea that oxidative stress causes cellular damage.[6] Many factors can cause this stress, including poor diet quality and alcohol consumption. Antioxidants protect the type of cells that are damaged in eye disease.[13] However, controversy arises when the form of antioxidants is discussed—whether they're more effective as part of a whole food (eg, lutein in dark leafy greens) or as a supplement.

The antioxidants most commonly associated with eye disease are vitamins C and E, carotenoids (particularly beta-carotene), lutein, and zeaxanthin. These are widely believed to reduce the risk of chronic eye disease, specifically cataract development and progression of early- to late-stage AMD.[12,14] Both early- and late-stage AMD are less prevalent in Asian than in American populations, which may be associated with diet quality. The standard Western diet provides a lower concentration of antioxidants than does the typical Japanese diet.[6]

Dietary sources of lutein and zeaxanthin include orange and green produce. High concentrations of these antioxidants are found in kale, spinach, lettuce, collard greens, cucumbers, parsley, celery, broccoli, pumpkin, summer squash, corn, green peppers, green beans, green olives, and green peas.[15] The antioxidant beta-carotene is plentiful in carrots.

Vitamin A

Vitamin A is a fat-soluble vitamin involved in eye development. In studies, supplemental vitamin A has no effect on glaucoma occurrence.[13] Conversely, a cross-sectional analysis of 662 black women showed that intake of fruits and leafy green vegetables high in vitamin A showed a possible reduction in glaucoma risk.[13] A similar study of 1,155 women found that general produce consumption supported the same outcome with an even stronger association.

Participants who ate less than one serving per month of these fruits and vegetables were more likely to develop glaucoma.[13]

Dietary sources of vitamin A include dark green produce (eg, kale/turnip/mustard/collard/beet greens, broccoli), orange produce (eg, carrots, sweet potatoes, cantaloupes, papayas, apricots), red and pink produce (eg, pink grapefruit, red peppers), liver, egg yolks, whole milk, and cheddar cheese.[15]

Vitamin C

Vitamin C is a water-soluble vitamin that's a cofactor for many enzymatic reactions in the body. It also functions as an antioxidant.

Both high and low supplementation levels of vitamin C have been associated with a decreased risk of glaucoma development, but this outcome isn't consistent with serum levels of vitamin C.[7,13] The American Optometric Association states that consumption of vitamin C can decrease the risk of cataract development and that when consumed as part of an overall healthful diet it can slow the progression of AMD and loss of visual acuity.[14]

Dietary sources of vitamin C include citrus fruits, red and orange produce (eg, tomatoes, cantaloupes, peppers), green produce (eg, broccoli, Brussels sprouts, peppers, cabbage), cauliflower, and berries.[15]

Vitamin E

Vitamin E is a fat-soluble vitamin that works with vitamin C to protect against free radicals in the eye; vitamin E deficiency is associated with retinal impairment.[7,14]

Dietary sources of vitamin E include dark green leafy vegetables, fortified cereal grains, vegetable oils (particularly wheat germ oil), avocados, butter, and proteins such as egg yolks, organ meats, seafood (particularly shrimp and sardines), and nuts/seeds.[15] Individuals with high cholesterol should be encouraged to limit consumption of higher cholesterol foods in favor of plant-based options low in cholesterol and saturated fats.

Oxidants

Iron and calcium, both considered oxidants, compete for absorption in the same pathways. Reviews of epidemiologic studies suggest an association between iron and calcium consumption and increased glaucoma development.[13,16] National Health and Nutrition Examination Survey (NHANES) data were used to establish a link "between a participant's previous self-reported glaucoma diagnosis and supplementation with oxidants calcium and iron"; 3,833 participants were evaluated.[13] Consumption of both minerals simultaneously or at high levels (>800 mg/day supplementary calcium or >18 mg/day supplementary iron) increased the probability of glaucoma in self-reported undiagnosed patients.[13] Again using NHANES 2005–2008 data, the same researchers studied the dietary consumption of calcium and iron data in 6,316 participants using a 24-hour

dietary recall conducted by a dietary interviewer. Interestingly, dietary consumption of both minerals had the opposite effect and was associated with a decreased glaucoma risk.[13,16] Clinical recommendations for physicians are to encourage supplementation of calcium and iron in patients only with recognized deficiencies and diagnosed glaucoma.[13]

Omega-3 Fatty Acids

Essential fatty acids aid visual development and retinal function.[14] DHA is found in photoreceptors in the eye, and EPA aids in DHA production. Observational data propose that dietary consumption of omega-3 fatty acids are "associated with a reduced risk of advanced AMD."[12] Self-reported data regarding omega-3 fatty acid intake from 1,837 participants in the AREDS study showed that high intake (0.11% total energy) slowed progression of moderate to advanced AMD by 30%.[6]

Blood flow, blood pressure, and intraocular pressure are all improved when omega-3 fatty acids are a regular part of the diet.[2] Sources of omega-3 fatty acids include cold water fish such as salmon, sardines, and halibut.

Micronutrients

Micronutrients play an essential supporting role in maintaining eye health. They prevent macular damage, possess anti-inflammatory properties, and support healthy eye function.

Thiamin

Thiamin is a water-soluble B vitamin that helps carbohydrates turn into energy and is involved in muscle contraction and nerve signaling. Like antioxidant consumption, thiamin consumption, particularly that from whole grain bread, has been associated with a lower glaucoma prevalence.[2] High dietary intakes of thiamin also are associated with decreased risk of nuclear cataract and vision change, though the pathophysiology is unknown.[17]

Dietary sources of thiamin include wheat germ, enriched and fortified whole grain products (eg, bread, cereal, flour, pasta, and rice), and protein (eg, eggs, dried milk, legumes, seeds, nuts, beef liver, and pork).[17]

Zinc

Zinc helps vitamin A produce melanin and is found primarily in the retina and choroid (underlying vascular tissue) in the eye.[14]

Dietary sources of zinc include protein (eg, lean meat, seafood, eggs, cheese, soybeans, and peanuts), green leafy vegetables, and bran.[15]

Dietary Recommendations

AREDS recommends that individuals consume nutrient-dense foods throughout the life span to protect the eyes from AMD, cataracts, and other eye disease.[10]

Produce

Fruits and vegetables rich in antioxidants, particularly vitamins A and C and the carotenoids, have been associated with a decreased likelihood of glaucoma in both black and white women over the age of 55.[2,13] The fruits and vegetables that had the most pronounced effect were dark leafy greens such as kale and collard greens, dried and canned peaches, oranges, and carrots.[2,13] Clinical recommendations include consuming at least three servings of dark green and orange produce daily.[2,13]

Caffeine

Caffeine intake should be monitored in those individuals with preexisting glaucoma, particularly women, because it can constrict the flow of blood to the eyes, which can negatively affect intraocular pressure.[2] Research shows that intraocular pressure can be increased by 1 to 4 mm Hg after consumption of 8 oz of coffee and that the effect can last up to 90 minutes.[18] The Australian Blue Mountains Eye Study found that glaucoma patients who routinely drank coffee had higher intraocular pressure than did those who consumed no coffee; the difference between the two groups was 2.8 mm Hg.[18] In a prospective study, a link was seen between heavy caffeine consumption (>500 mg per day) and the development of glaucoma compared with low caffeine consumption (<125 mg per day).[13] Clinical recommendations include encouraging individuals diagnosed with glaucoma to refrain from ingesting caffeine before a procedure that measures intraocular pressure and to regularly consume fewer than three cups of coffee or less than 250 mg caffeine/day.[2,13] More research may be needed to determine whether heavy, prolonged caffeine consumption (>5 cups coffee/day or >500 mg caffeine/day) worsens intraocular pressure in diagnosed glaucoma patients.[13]

Alcohol

The data on alcohol consumption and eye disease are mixed, with both positive and negative correlations with glaucoma. Several studies have shown that, depending on the quantity, alcohol quickly and briefly lowers intraocular pressure, but daily consumption is inversely linked to low intraocular pressure.[18] Researchers hypothesize that consuming one to two alcoholic drinks daily may reduce glaucoma risk; a prospective study identified a statistically insignificant inverse association between consuming two or more drinks per day and glaucoma incidences.[18] Clinical recommendations include encouraging patients to adhere to the Dietary Guidelines' recommendations of one or fewer drinks per day for women and two or fewer drinks per day for men.

Omega-3 Fatty Acids

Increased consumption of essential fatty acids can be protective against the development of AMD. Both the Blue Mountains Eye Study and EUREYE, the European Eye Study, recommend consuming one serving of oily fish per week to decrease the odds of developing early AMD by up to 50%.[6] A population-based study in France supported these findings and suggested that consuming oily fish

more than once per month could decrease AMD development by 60%; supplementation with omega-3s hasn't yielded the same results.[6] Clinical recommendations include consuming a source of omega-3 fatty acids in the form of oily fish once per week as part of an overall healthful dietary pattern.

Low-Glycemic Index Diets

A low-GI diet may be beneficial for individuals with diabetes or AMD, or who are at risk of developing either disease.[10] Low-GI diets encourage the consumption of foods that have a low impact on blood sugar levels based on quality of carbohydrates and dietary fiber content.[19] It's hypothesized that the typical American diet, which is generally regarded as high GI, is associated with elevated rates of eye disease.[20]

A food frequency questionnaire was given to study participants who were at risk of developing early-stage AMD and who hadn't been diagnosed with diabetes; the majority of patients were white women older than 49 at baseline.[19] Consumption of vegetables, fish, fat, fiber, and a variety of micronutrients was studied. Results showed no correlation between total carbohydrate consumption and early-stage AMD risk, which suggests that it's not the quantity of carbohydrates per se but possibly their postprandial effects that are important.[19] Researchers identified a positive correlation between a more healthful diet (defined as increased fruit and vegetable consumption and no smoking) and a low-GI diet, which they associated with a lower risk of developing early-stage AMD.[19] Cereal fiber also was linked to a reduced risk of developing early-stage AMD, though there was no significant association between the average GI of foods consumed, cereal fiber, carbohydrates, and the 10-year occurrence of late-stage AMD.[19] These results provide a basis for a clinical recommendation that increased fruit, vegetable, and cereal fiber consumption as part of a low-GI diet can be beneficial in preventing early-stage AMD.

Supplements

Many Americans choose to take supplements in lieu of adding healthful whole foods to their diets because of the convenience and "insurance" they believe supplements provide, regardless of their diet quality. The supplement business in America is now a multibillion-dollar industry, but questions about best practice remain.[4,15] Dietary supplements can have different effects on eye disease based on the type of disease and combination of nutrients. Supplementation with antioxidants, fat-soluble vitamins, and certain minerals has been theorized to halt the development or progression of eye disease when taken independently or in combination; AREDS and AREDS2 are primary examples. These supplements are hypothesized to be effective based on the fact that their nutrients are commonly found in foods thought to be eye protective. However, evidence that supplementation can prevent or delay the onset of eye disease is weak at best in most studies.

The FDA doesn't regulate supplements, and as many as 1 in 9 patients don't report supplement usage to their ophthalmologists.[7] The most common supplements people with eye disease take are vitamins A, C, and E and the minerals chromium and zinc. In research studies, participants often self-report supplement intake, so it can be difficult to establish whether supplementation is taken primarily to help slow eye disease or for other health related reasons. Many people mistakenly believe that though there may be no proven benefits associated with supplement usage, there's also no harm. Unfortunately, problems can arise when vitamins and minerals are taken in excess, especially if the individual's ophthalmologist isn't informed of their intake. Vitamin A toxicity can lead to enlarged organs, headaches, nausea/vomiting, vision disturbances, and itchy skin.[15] Excessive vitamin C intake can cause digestive issues, kidney stone formation, potential interference with blood sugar testing, and decreased absorption of the minerals selenium and copper.[15] Too much supplemental vitamin E can increase LDL cholesterol.[15] Excess chromium can cause iron deficiency anemia, and zinc toxicity leads to mineral imbalances.[15]

Smoking also can influence the safety and efficacy of nutrient supplementation. Beta-carotene has been linked to an increased risk of lung cancer in individuals who recently have stopped smoking.[10] Smokers who use supplements to delay or prevent eye disease should be aware of the risk and discuss supplementation with their ophthalmologist; a supplement free of beta-carotene like AREDS2 may be more appropriate for this population.[10]

Areas for Further Research

The current understanding of the relationship between sugar intake, aging, eye function, and the microbiome is limited, and further exploration of metabolic pathways is necessary.[20] Other areas of interest include the impact of protein damage and inflammation, particularly as it relates to AMD and cataracts.[20] The creation of public health tools, such as an analysis of dietary patterns of individuals with eye disease, also would be an asset.[20] These tools could aid researchers in more effectively establishing innovative therapies to counteract the high-GI Western diet.

Limitations

Many studies were limited due to their sample size, classification of disease stage, or self-reported intake of supplements and/or diet. These potential misrepresentations of diet quality, intake, and level of disease progression could contribute to incomplete or incorrect theories on the effectiveness of certain dietary patterns or supplementation and negatively impact clinical recommendations. Prospective studies in a wider population are needed to standardize clinical recommendations to help prevent eye disease across populations.[19]

Putting It Into Practice
With the prevalence of eye disease doubling in older Americans over the next 35 years, there's an urgency for dietitians to get involved to help clients reduce their risks. Developing clinical education materials, conducting dietary research, and forming relationships with ophthalmologists to bring nutrition counseling into their practices are all building blocks to decrease eye disease development and progression.

Though dietary information and clinical recommendations are limited and even contradictory in some cases, dietitians should encourage regular consumption of studied nutrients in whole foods to slow eye disease development and progression. Results may not be conclusive as to the benefits for those with eye disease, but the rewards of increasing produce, whole grains, and omega-3 fatty acid consumption far outweigh the potential risks of obtaining similar nutrients through supplementation. Greater benefits of adding whole, nutrient-dense foods to the diet while potentially replacing less-nutritious, calorie-dense foods include improving blood pressure, cholesterol, and weight, all of which are comorbidities of eye disease. Many of the nutrients associated with potential benefits for eye disease come from similar sources, which should help clients reach dietary goals of consumption. As research continues to strengthen the relationship between nutrition and eye health, dietitians should be able to translate the science into practical application for consumers.

—Alexandria Hardy, RDN, LDN, is a consultant in corporate wellness and a freelance food and nutrition writer based in Pennsylvania.

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Quiz

1. Which of the following is the greatest risk factor for the development of an eye disease?
A. Age
B. Gender
C. Race
D. Diet

2. What is the expected incidence of age-related macular degeneration (AMD) in 2050?
A. 1.3 million
B. 2.7 million
C. 5.4 million
D. 8.1 million

3. Which of the following foods is an excellent source of vitamin A?
A. Blueberries
B. Pineapple
C. Mushrooms
D. Turnip greens

4. Approximately how many patients don't disclose supplementation usage to their ophthalmologists?
A. 1 in 5
B. 1 in 15
C. 1 in 9
D. 1 in 20

5. Chromium toxicity can result in which of the following?
A. Digestive issues
B. Iron deficiency anemia
C. Headaches
D. Kidney stones

6. What color produce should dietitians recommend to help counter the effects of eye disease?
A. Dark green and orange (broccoli, papaya)
B. Yellow and white (onions, bananas)
C. Brown and white (mushrooms, coconuts)
D. Purple and blue (eggplant, blueberries)

7. Which of the following populations is most likely to develop cataracts?

A. White American women over the age of 40
B. Black American women over the age of 50
C. Hispanic American men over the age of 40
D. White American men over the age of 50

8. Which of the following groups is at the highest risk of developing glaucoma?
A. All women over the age of 60
B. Hispanic Americans over the age of 30
C. Asian men over the age of 50
D. Black Americans over the age of 40

9. What is an appropriate clinical recommendation regarding oxidants?
A. Supplement iron in all patients at risk of developing eye disease.
B. Supplement calcium and iron only in patients with recognized deficiencies and diagnosed glaucoma.
C. Supplement calcium in all patients at risk of developing eye disease.
D. Consume dietary sources of iron and calcium in patients at risk of eye disease.

10. What is the potential impact of caffeine on eye disease?
A. It constricts blood flow to the eyes.
B. It decreases intraocular pressure.
C. It decreases the risk of developing AMD.
D. It limits production of drusen.