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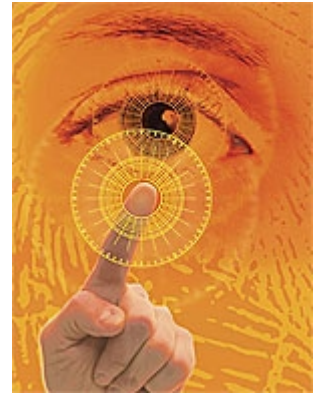
REPORT

Relieve Your Tired Eyes While Guarding Against Common Eye Diseases

By Laurie Barclay, MD

Today, nearly everyone uses a computer either for work or leisure. Not surprisingly, the resulting eye fatigue from computer use affects all ages.^{1,2} Experts agree that proper care and prevention are crucial to avoid the potential complications of eye fatigue, such as eye weakness, eye irritation, and poor ability to focus on objects at different distances.

According to several studies, a natural supplement known as astaxanthin may play an important part in proper eye care and prevention.³⁻¹⁰ Not only does astaxanthin help prevent eye fatigue and improve visual acuity—studies suggest that its potent properties may also hold important applications in promoting cardiovascular health, enhancing athletic endurance, and beautifying the skin.



EYE FATIGUE: A MODERN EPIDEMIC

Despite the many benefits of our world's increasing dependence on computer technology, one of the drawbacks is eye fatigue resulting from hours of staring at a visual display terminal (VDT). Even with optimal lighting, ergonomics, and visual correction, a full work week spent at a computer terminal takes its toll on eye muscles, which become fatigued and weakened over time. Further complicating the widespread problem of eye fatigue is depletion of the ozone layer, which has eroded our protection from the damage that solar ultraviolet (UV) rays can inflict on the skin and eyes.

This insidious attack on eye health now begins at an even earlier age, as young children play handheld video games for long periods. Hours spent focusing on the small screens take away from time playing ball or other activities requiring changes in direction of gaze and in visual accommodation that keep eye muscles healthy and in good shape.

Eye fatigue, or asthenopia, is an eye condition characterized by several symptoms including eye weakness, eye irritation, and poor accommodation. Scientist Jowell G. Bolivar, PhD, from Fuji Health Science, Inc., tells *Life Extension* magazine, "Accommodation is the change of the refractive power of the eye to focus objects at different distances." Most visual problems associated with accommodation occur when this process is too slow, diminishing the ability to quickly focus on objects at different distances.



Other symptoms of eye fatigue may include sensitivity to glare, poor depth perception, and other visual symptoms that worsen from morning until night, particularly for individuals spending four to seven hours daily or more watching a VDT. This type of prolonged close work hinders accommodation, or the ability of the eye to shift comfortably from close work to distance vision. Long hours of VDT use may affect performance of a structure known as the ciliary body of the eye, which controls lens refraction.^{1,2}

Much as the lens of a camera can adapt to focus on near or far objects, the ciliary body of the eye allows us to do the same. When the ciliary muscle within the ciliary body relaxes, it flattens the lens, allowing us a broader, more panoramic view. When the ciliary muscle contracts, the lens becomes more convex, narrowing our focus on near objects. Just as our arm and leg muscles get tired from heavy workouts, the ciliary muscle becomes fatigued when long periods of focusing on near objects require that it stay contracted for a long time.

ASTAXANTHIN REDUCES EYESTRAIN

Results of well-controlled trials in human volunteers suggest that the carotenoid antioxidant astaxanthin can help prevent

eyestrain, known technically as asthenopia.

The evidence largely comes from Japanese clinical studies performed by Dr. Shigeaki Ono and his colleagues in Sapporo. Commenting on these studies, Paul S. Bernstein, MD, PhD, Mary Boesche Professor of Ophthalmology and Visual Sciences at the University of Utah School of Medicine in Salt Lake City, tells *Life Extension*, **“In his randomized, placebo-controlled studies, he showed that accommodative amplitude increased and symptoms of eyestrain decreased in the subjects who took astaxanthin supplements.”**^{3,4}



In a study of 26 VDT workers randomly assigned to receive 5 mg astaxanthin per day or placebo for one month, those who received astaxanthin had a 54% reduction of eye fatigue complaints and objective improvements in accommodation ability, even though neither the patients nor the researchers evaluating them knew which patients were assigned to astaxanthin.⁵

Interestingly enough, only the astaxanthin group showed significant reduction of subjective symptoms. After four weeks of 5 mg astaxanthin treatment, the power of accommodation was significantly improved. On the other hand, placebo did not show any significant difference.

Other studies^{3,6} have looked at the effects of different doses of astaxanthin on accommodation contraction time. Positive accommodation refers to the time required for the ciliary muscle to contract sufficiently to change the focus from distance vision to close-up or near vision. Shorter accommodation contraction time indicates less eyestrain and better eye health.

Significant improvements in reducing asthenopia and positive accommodation occurred for the 4 mg and 12 mg astaxanthin groups. Accommodation contraction time was significantly shortened in the 4 mg and 12 mg groups, compared with that before treatment.^{3,6}

In a similar study,³ volunteers who took astaxanthin, 12 mg/day for four weeks, had significant improvements in positive accommodation. Those given 6 mg astaxanthin had a tendency for improved accommodation amplitude, meaning that they were able to switch focus over a greater range of visual distance.

As we slave away at our computers, bombarding our eyes with bright light and visual stimulation at a close distance, the natural result is that accommodation contraction time increases, causing eye fatigue. Amazingly, other Japanese studies^{7,8} have shown that supplementation with astaxanthin prevented some of that increase. Even better, taking 6 mg astaxanthin daily also helped prevent increases in negative accommodation, or the time required to shift focus from close work to far-distance vision.^{3,7,8}

A similarly designed, double-blind, well controlled study showed that accommodation power increased and symptoms of eye fatigue decreased in healthy volunteers given astaxanthin, 6 mg/day for four weeks, compared with those who did not receive this supplement. Reassuringly, the researchers also concluded that on the basis of laboratory tests and other monitoring, “astaxanthin was confirmed to be completely safe.”⁴



These findings suggest that astaxanthin may help decrease eye fatigue, which allows faster recovery of the eye fatigue induced by visual work. Astaxanthin attenuates induced eye fatigue as opposed to treating eye fatigue, which suggests prevention rather than treatment benefits. Astaxanthin-treated groups were able to recover more quickly than the control group after a heavy visual stimulus.

A study in athlete volunteers showed that depth perception and critical flicker fusion, an objective measure of visual acuity, improved by 46% with astaxanthin supplementation, 6 mg/day. In addition, lactic acid build-up in muscles, which normally contributes to exercise-related muscle cramps and fatigue, was significantly reduced in 1,200-meter runners who took astaxanthin. These results suggest that astaxanthin may enhance sports performance.⁹

Two studies^{10,11} helped to shed some light on one of the possible mechanisms by which astaxanthin supplementation may combat eye fatigue. Compared with control subjects, those given 6 mg astaxanthin daily had improved blood flow to the small blood vessels in the retina, which is a specialized layer that transmits visual information reaching the back of the eye, and potentially to the ciliary muscle.

Thus, in addition to alleviating accommodation in eye fatigue or asthenopia, astaxanthin supplementation also improves retinal blood flow. Given the observed blood flow improvement measured in the retinal capillary vessels, it is likely that more blood reaches the ciliary body and provides nourishment to the ciliary muscles.

So far, trials in human volunteers carried out by six independent ophthalmological institutions in Japan ^{3-7,11} showed that

astaxanthin effectively reduced eyestrain by improving accommodation, reducing eye-muscle irritation, allowing the ciliary body to recover faster, stimulating blood flow to the retina, and reducing inflammation.¹² Astaxanthin supplementation at 6 mg for four weeks improved symptoms associated with tiredness, soreness, dryness, and blurry vision.

WHAT YOU NEED TO KNOW: ASTAXANTHIN

- Astaxanthin is a carotenoid xanthophyll, found naturally in the *alga H. pluvialis*, which gives lobster and other marine life consuming it a reddish hue.
- Numerous clinical studies have shown that astaxanthin reduces eyestrain and eye fatigue by improving accommodation, or the ability to shift focus from close-up to long-distance vision and vice versa.
- The mechanisms of action of astaxanthin in reducing eyestrain may include improved blood flow to the ciliary muscles controlling accommodation, as well as anti-inflammatory and antioxidant effects.
- The unique structure of astaxanthin allows it to span both layers of the cell membrane, where it can efficiently trap free radicals both outside and within the cell to reduce oxidative injury.
- These healthful effects of astaxanthin may also apply to cardiovascular disease, cancer, diabetes, ulcer disease, weight control, and overall health of skeletal and heart muscle, skin, and kidneys.
- Studies suggest that 6 mg astaxanthin daily, in combination with lutein and zeaxanthin, could help promote eye health. No harmful effects have been noted, and astaxanthin has been deemed “completely safe.”
- Because of its benefits on visual function, endurance exercise, and weight control, astaxanthin supplementation may enhance sports performance.

ASTAXANTHIN PROTECTS AGAINST FREE RADICAL DAMAGE

Nutrition-conscious individuals have long eaten carrots for better eyesight, since carrots are rich in beta-carotene that may help prevent visual problems. However, much richer sources of beta-carotene and other carotenoids have been discovered.

Astaxanthin is an oxygenated carotenoid, in the class of plant compounds known as xanthophylls, found naturally in the microalga *Haematococcus pluvialis*.¹² This alga is widely abundant in bodies of water ranging from freshwater rock pools to arctic oceans. Salmon, shrimp, lobster, and other marine life that are colored pink and red owe their hues to their diet rich in astaxanthin.¹³

Algae thrive in waters exposed to intense light. Ultraviolet radiation in sunlight generates free radicals that damage DNA and other vital cellular structures, resulting in sunburn or even skin cancer in humans. But thanks to the antioxidant activity of astaxanthin,^{12,14} the algae containing this carotenoid are protected from UV damage, allowing them to flourish even in direct sunlight.

Astaxanthin’s mechanism of visual benefits is uncertain, but all carotenoids are excellent antioxidants, so its antioxidant capacity may be part of the mechanism. Notes Dr. Bernstein, “The ciliary body is the muscle involved in accommodation, and research in my lab-oratory has shown that it is a carotenoid-rich tissue.”

Research into the antioxidant activity of astaxanthin has shown that its mechanism of action may be complementary to that of vitamin E, a different kind of antioxidant that is also important in eye health and which may help protect against age-related macular degeneration.¹⁵ Free radical damage by UV light or other types of injury involves spread of subatomic, negatively charged particles known as electrons. Astaxanthin is a chemical compound that can accept electrons easily, absorbing free radicals and stopping the chain reaction of tissue damage.¹⁶



Vitamin E and astaxanthin appear to have different reaction mechanisms to scavenge free radicals, which could be very important.” Dr. Ana Martinez, a scientist at Instituto de Investigaciones en Materiales, Universidad Nacional Autónoma de México, tells *Life Extension*, “We studied several substances and we found that vitamin E is the best antiradical concerning the electron donor capacity, and the best antiradical concerning the electron acceptor capacity is astaxanthin.” This mechanism may help scientists better understand astaxanthin’s potential role in averting eye fatigue.

Because astaxanthin is highly fat soluble, it has an affinity for cell membranes, which are vitally important to eye health and to cellular function in general. These membranes are largely composed of lipids or fats arranged in a double layer around the perimeter of the cell, so they are often referred to as bilipid membranes. Compared with vitamin E, astaxanthin has far greater antioxidant activity within lipid structures.¹⁷

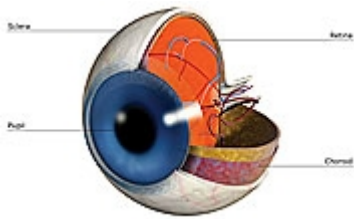
Even better in terms of its unique protective ability is that astaxanthin spans the thickness of the double layer cell membrane, with portions exposed both within and outside of the cell to attack free radicals in both locations, affording better cellular protection. This orientation of astaxanthin also helps to stabilize the cell membrane.¹⁸

By spanning the cell membrane, astaxanthin can also function as a bridge, transporting trapped free radicals to predominantly water-containing regions of the cell, where they can be further neutralized by water-soluble antioxidants. In contrast to astaxanthin, beta-carotene is located only within the bilipid membrane and vitamin C is located only on the cell surface, outside the bilipid membrane.¹⁷

OTHER BENEFITS OF XANTHOPHYLLS FOR VISION

In addition to their effects on eyestrain, xanthophylls have been directly linked to lower risk of cataract formation and age-related macular degeneration,^{13,14} which is the leading cause of legal blindness for people over 55 years of age in the Western world.

Age-related macular degeneration is particularly disabling because the macula is a small, specialized spot within the retina that allows detailed central vision for tasks such as reading.



Experiments in laboratory animals suggest that the anti-inflammatory effects of astaxanthin help prevent changes in blood vessels contributing to the visual loss resulting from age-related macular degeneration¹⁹ and help alleviate the form of eye inflammation known as uveitis.^{20,21} In uveitis, animal experiments showed that astaxanthin in a range of doses had the same anti-inflammatory action as the steroid prednisolone, resulting in reduced levels of markers of inflammation such as nitric oxide synthase, prostaglandin E2, and TNF-alpha.²¹ Other reduced biomarkers were cellular infiltration and protein build-up.

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Recent research²² shows that, compared with beta-carotene, xanthophylls (such as astaxanthin, zeaxanthin, and lutein) are twice as likely to be taken up by retinal cells, allowing preferential accumulation of xanthophylls in the macula of the retina, where they may protect against inflammation and UV-related and other free radical damage underlying age-related macular degeneration.

An Italian study²³ showed that astaxanthin can actually improve visual function in patients who are in the early stages of age-related macular degeneration.

In this study, 27 patients with mild changes in visual acuity from age-related macular degeneration were randomly assigned to receive an antioxidant supplement daily for one year or to receive no supplement. In addition to 4 mg astaxanthin, the supplement contained 10 mg lutein, 1 mg zeaxanthin, 180 mg vitamin C, 30 mg vitamin E, 22.5 mg zinc, and 1 mg copper.

The patients had electroretinograms, which are sophisticated, objective tests of visual function, at six months and at one year after enrolling in the study. Amazingly, highly significant improvements in central vision, but not in peripheral vision, were seen at both time points in the patients who received the antioxidant supplement containing xanthophylls, but not in those patients who did not take the supplement.²³ This corresponds well with the preferential accumulation of xanthophylls in the macula supplying central vision,²² as described above.

OTHER HEALTH BENEFITS OF ASTAXANTHIN

As discussed above, astaxanthin may reduce eyestrain by improving blood flow to the ciliary muscles. An overall health benefit of astaxanthin may be its ability to improve circulation by modifying the flow characteristics of blood. In a study of 10 healthy men in their fifties, those who received 6 mg astaxanthin daily for 10 days had significantly faster blood flow than those who did not take astaxanthin, and there were no harmful effects.¹¹

Therefore, the benefits of astaxanthin for eye health in some ways reflect the protective effects of astaxanthin on cardiovascular health.¹⁴ Animal experiments have shown that astaxanthin may lower high blood pressure, prevent stroke, protect against vascular forms of dementia, and help prevent vascular changes and atherosclerosis resulting from high blood pressure and from abnormal lipid profiles.^{12,14,24-27}

Just as astaxanthin combats eyestrain by reducing inflammation in the ciliary muscle, it appears to have similar anti-

inflammatory and antioxidant protective effects on skeletal muscle and even on heart muscle. Research has shown that mice given astaxanthin in their diet were protected from oxidative damage caused by strenuous exercise on a treadmill, both in the gastrocnemius (calf muscle) and in the heart.²⁸

These findings show that astaxanthin is indeed absorbed and transported into skeletal muscle and heart in mice. This work demonstrated astaxanthin's ability to attenuate numerous forms of oxidative metabolites.

Astaxanthin supplementation also improved swimming endurance in mice by increasing utilization of fatty acids, which also significantly decreased fat accumulation.²⁹ A subsequent study by the same researchers showed that in obese mice fed a high-fat diet, astaxanthin supplementation inhibited increases in body weight and fat and reduced triglycerides and total cholesterol, suggesting that "astaxanthin might be of value in reducing the likelihood of obesity and metabolic syndrome in affluent societies."³⁰

Astaxanthin has far-reaching effects on numerous markers of inflammation and free radical damage, including prostaglandin E₂, cyclooxygenase-2, TNF-alpha, and interleukin-1beta.³¹⁻³³ Because of this potent anti-inflammatory and antioxidant activity, astaxanthin may offer hope for a wide variety of chronic diseases including heart disease,²¹ cancer,³⁴ diabetes-related kidney disease,^{35,36} and peptic ulcers related to bacterial infection with *Helicobacter pylori*.³⁷⁻³⁹ Studies have even shown cosmetic benefits of astaxanthin supplementation on skin appearance.^{40,41} Astaxanthin seems to work by diminishing proinflammatory responses that would otherwise perpetuate local sites of inflammation.

Because of preliminary evidence suggesting that astaxanthin supplementation may be promising in the areas of diabetes,^{35,42} weight management,³⁰ and high blood pressure,^{12, 24-26} scientists are considering additional research on potential uses of astaxanthin for prevention and treatment of conditions related to the metabolic syndrome.

Beyond its benefits for eye health, astaxanthin thus appears to be an important nutrient that may help increase physical endurance and reduce muscle damage, improve skin health parameters such as skin moisture and elasticity, boost gastric health by reducing infection and inflammation with *Helicobacter pylori*, support weight loss by increasing body fat utilization in combination with exercise, and support kidney health. Because of its ability to improve visual function, endurance exercise, and weight control, astaxanthin supplementation may enhance sports performance.⁹

PRACTICAL CONSIDERATIONS

Not only has astaxanthin supplementation been shown to relieve symptoms of eye fatigue, it also has other potential benefits for visual function and for overall health, thanks to its antioxidant and anti-inflammatory effects.

Because of its unique structure and physiological properties, astaxanthin has the potential to work together with other antioxidants and xanthophylls, enhancing their ability to promote eye health. Scientists believe that other carotenoids, such as lutein and zeaxanthin, may have a similar beneficial effect on symptoms of eye strain.

Xanthophylls such as lutein, zeaxanthin, and astaxanthin are all useful in eye health because of their ability to cross the blood- and eye-brain barrier. Lutein and zeaxanthin help prevent light-mediated free radical damage to the retina, with zeaxanthin localized in the retinal cone cells in the macula involved in color vision, and lutein in the periphery of the retina in the rod cells involved in black and white vision. Astaxanthin, on the other hand, concentrates in the iris-ciliary muscle of the eye, which may contribute to the improvement of ciliary body function. Additionally, astaxanthin has been shown to be a stronger antioxidant than lutein and zeaxanthin.



Astaxanthin is thus emerging as an optimal choice to complement lutein and zeaxanthin already found in the diet and in nutritional supplements, and it should be the first choice for eye care supplementation for the management of eye-related oxidative stress. Current human clinical tests established that 2-44 mg/day showed no observed adverse effects. In clinical trials to date, doses of 4 to 12 mg daily appear to be effective for symptoms of eyestrain without any apparent adverse effects.⁹ Early research suggests that the cardiovascular health benefits of astaxanthin may begin at doses as low as 4 mg/day.⁴³ To capture the nutrient's varied benefits, many practitioners recommend at least 6 mg/day of astaxanthin.

If you have any questions on the scientific content of this article, please call a Life Extension Health Advisor at 1-800-226-2370.

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