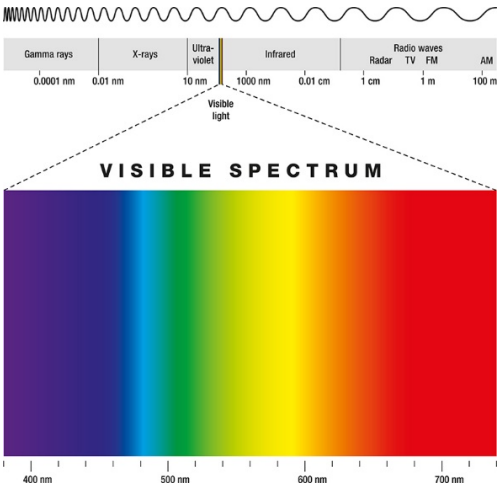
WHITE PAPER:

BLUE LIGHT, SLEEP QUALITY AND THE NEW ROLE OF MACULAR CAROTENOIDS IN A DIGITAL WORLD

With B.L.U.E. Study Data

OmniActive
HEALTH TECHNOLOGIES

BLUE LIGHT, SLEEP QUALITY AND THE NEW ROLE OF MACULAR CAROTENOIDS IN A DIGITAL WORLD

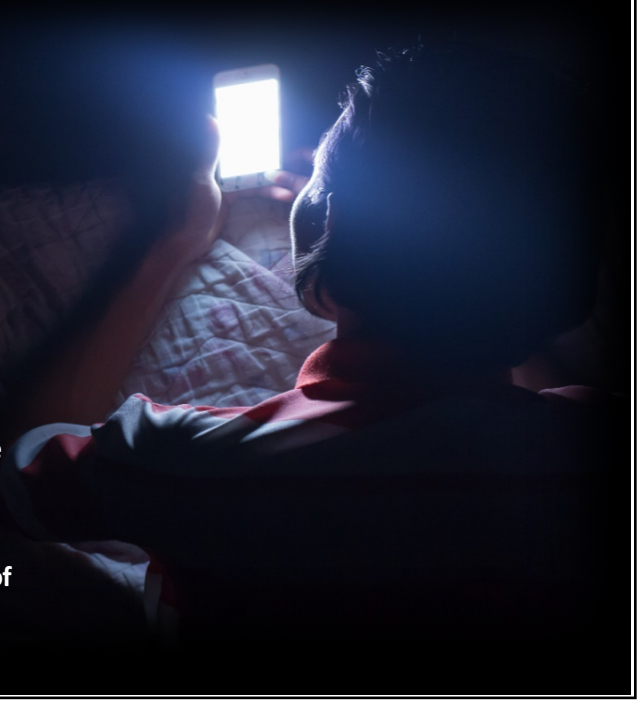


Visible light is composed of wavelengths of energy ranging from 390 to 700 nanometers with each being perceived as a different color. Within the violet/blue wavelength range lies a narrow band of high-energy blue light (390-500 nm) and sunlight is our largest source of exposure. Over the past two decades, however, other man-made sources have only further increased the amounts of blue light to which we are exposed. For example, “cool” LED lights emit a large amount of light in the 420-500 nm range and compact fluorescent bulbs emit blue light in the 400-500 nm range. In addition to modern light sources, common digital devices (400-520 nm), computer screens (420-520 nm), and televisions (400-520 nm) also emit high-energy blue light.

Even though the light emitted from these devices is substantially less than natural sunlight, their usage has grown dramatically. Today, most people spend more time under artificial lighting, working in front of computer screens, interacting with smartphones and watching television. This dramatic rise in usage can pose problems.

Estimates from population studies indicate that the average American spends more than 10 hours per day viewing screens and the prevalence of digital device use is only increasing

- **Adults spend on average ~10.5 hours per day in front of media screens.**
- **The typical cellphone user touches his or her phone 2,617 time every day, while the heaviest user more than doubles that with 5,427 touches.**
- **Children ages 8 to 10 spend about 5.5 hours each day using media, but they’re actually exposed to almost 8 hours of media because of simultaneous multiple media use .**
- **Teens spend 9 hours a day using media. That’s more time spent than going to school.**
- **Seventy-two percent of children age 8 and under have used a mobile device for some type of media activity, up from 38% in 2011.**
- **In many cases, people may spend more time in front of screens than they do sleeping.**



The increased use of digital devices has been implicated in a constellation of symptoms manifesting as eye fatigue, eye strain and headaches. According to the National Institute for Occupational Safety and Health, these symptoms affect about 90% of people who spend at least three hours each day at a computer. A study of college students who used computers for 4-6 hours found that they were at a significantly higher risk of developing symptoms compared to those who used computers for less than 4 hours. As pervasive as these problems have become the almost constant exposure to blue light has raised new concerns that extend into the bedroom and well after the sun has set. Because blue light plays a role in regulating sleep/wake cycles, the need to "check in" before bedtime has led to a growing concern of its effects on sleep quality.

"…the eye is composed of two light-sensing systems: one that allows sight and a second, separate system that tells the body when it is day or night: time to sleep or wake."

Circadian Rhythm and the Eye Connection

Circadian rhythm entrainment—the synchronizing of the biological clock with environmental cues—acts as a reset mechanism to reflect the natural periods of light and dark and impacts overall timing and duration of sleep and wakefulness. This 24-hour pattern is predicated primarily on light/dark cycles that, for most of evolutionary history, have come from the sun. Light is the primary mediator of regulating the circadian rhythm and it wasn't until 2005 that researchers understood the retina's role in sleep/wake cycles.

The retina is the light sensitive layer of tissue at the back of the eye composed of a complex of structures. Like the film of a camera, it collects light and color that is ultimately perceived as images. Photoreceptor cells called rods and cones make up the layer of the retina that perceives color and allows for vision in dim light. But there is a third type of photoreceptor that plays no part in vision. Simply stated, the eye is composed of two light-sensing systems: one that allows sight and a second, separate system that tells the body when it is day or night: time to sleep or wake. These cells, called intrinsically photosensitive retinal ganglion cells (ipRGCs), only make up about 0.2% of the photoreceptor cells in the retina but are crucial for circadian rhythm entrainment. Acting similarly to a light meter, ipRGCs are most sensitive to wavelengths of light of approximately 480 nm. Once activated, they signal a region of the brain that acts as the "master clock," thus regulating our sleep/wake cycles by suppressing melatonin production and acting to reset the wake cycle in response to light. It is these cells that are implicated in the interaction between high-energy blue light from digital devices and poor sleep quality.

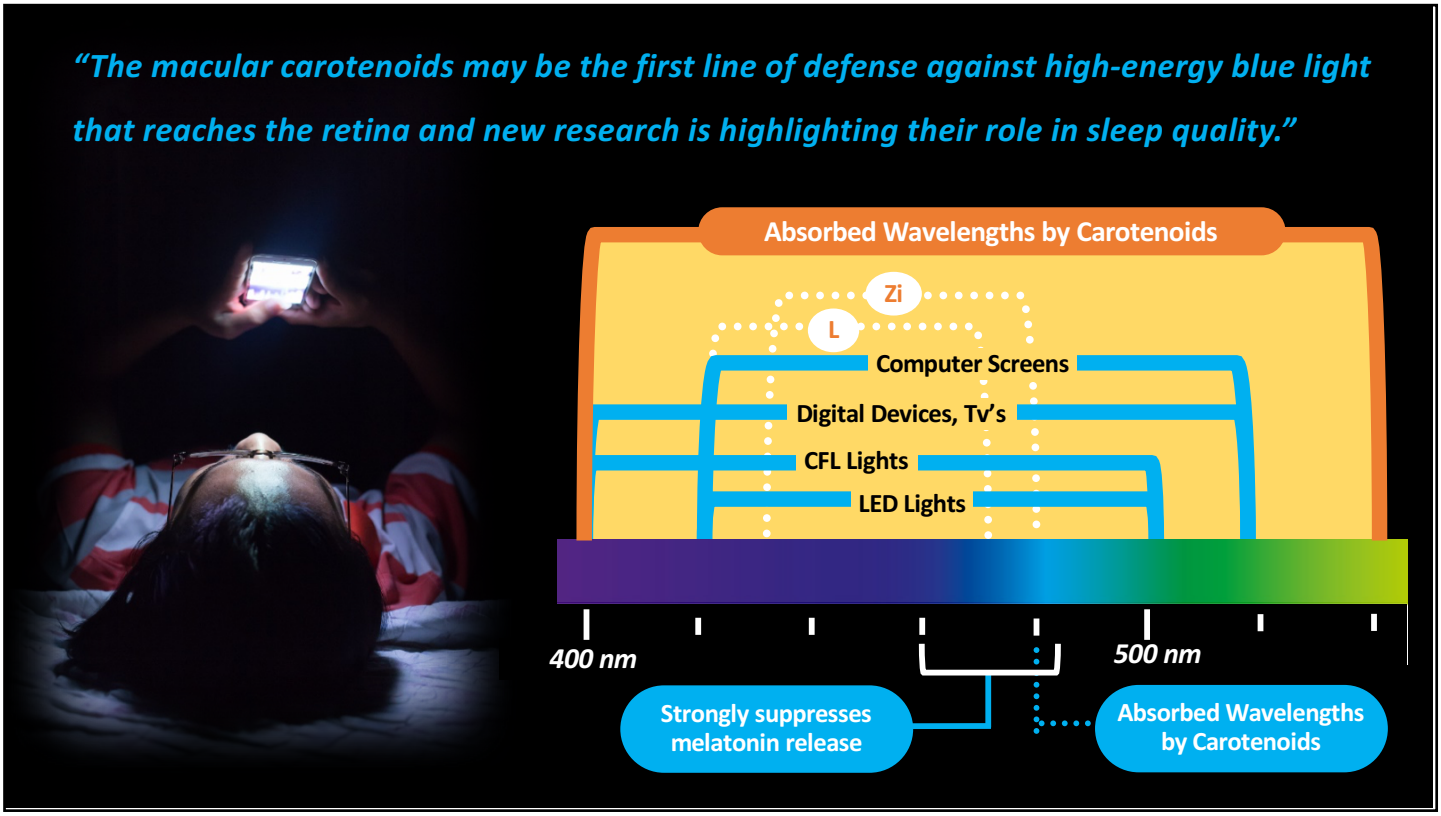
The ipRGC cells can be "turned on" at any time with light. Abrupt changes from dark to light when using digital devices can activate ipRGC cells sending mixed signals to the brain to "wake up" and affect sleep quality. While light of any kind can suppress melatonin secretion, blue light does so more strongly. Light at the 460-484 nm range, which is commonly emitted from various digital devices and energy-efficient LED/CFL lighting, strongly suppresses melatonin release.

Evening use of light-emitting e-readers can impair sleep, circadian timing and next-morning alertness. It has been reported that the use of self-luminous devices before bedtime can suppress melatonin by 7% to 23% and this number increases with the simultaneous use of LED lights. The influence of prolonged screen time and blue light on circadian rhythm underscore the need to take measures to counteract this influence. The macular carotenoids may be the first line of defense against high-energy blue light that reaches the retina and new research is highlighting their role in sleep quality.

Macular Carotenoids—Filtering Blue Light to Improve Sleep Quality

Carotenoids are organic pigments produced by plants and algae and are divided into two classes – carotenes and xanthophylls. Due to their yellow-red color, carotenoids generally absorb wavelength of light in the 400 – 550 nm range (violet to green light). Of the more than 700 carotenoids found in nature there are a little over 30 that are found in the diet. Only a portion of these are absorbed and, of those absorbed, only three are found in the eye – lutein, RR-zeaxanthin, and RS (meso)-zeaxanthin. These three carotenoids are deposited in the macular region of the retina and act as potent antioxidants and filters of high energy blue light. Specifically, lutein is known to absorb light in the 420-470 nm range whereas the zeaxanthin isomers absorb between 430-480 nm. A combination of all three macular carotenoids, therefore, absorb a broader range of the blue light spectrum. The science of blue light, its effects on vision and the role of macular carotenoids isn't new. However, the effects of lutein, RR-zeaxanthin and RS (meso)-zeaxanthin on sleep quality in subjects exposed to prolonged digital device use has not been evaluated. To address this, OmniActive sponsored the B.L.U.E. (Blue Light User Exposure) study.

"The macular carotenoids may be the first line of defense against high-energy blue light that reaches the retina and new research is highlighting their role in sleep quality."



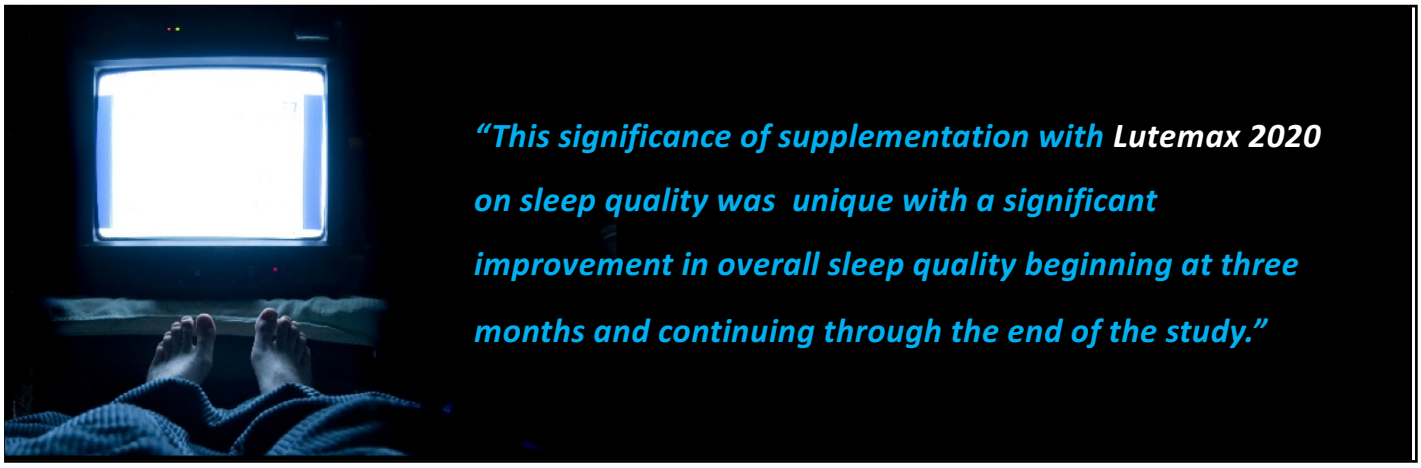
The B.L.U.E. Study Supports New Benefits for All Three Macular Carotenoids

Eye health supplements are a unique class of condition-specific formulas because they rank within the top five supplements that consumers are very likely to use. Nevertheless, actual use has been limited to either young (i.e. infants) or older populations where there is a developmental need or a need to prevent age-related eye diseases, respectively. The concept of long-term, preventive therapies has also hindered consumer acceptance and compliance. However, consumer acceptance substantially increases when the perceived benefits address a need rather than prevention. The B.L.U.E. study highlights new benefits of macular carotenoids that are relevant to today's consumers.

The B.L.U.E. study was a 6-month randomized, double-blind, placebo-controlled trial conducted at the University of Georgia that examined the importance of supplementation with macular carotenoids from Lutemax 2020 on visual health and performance, physical indicators of excessive screen time and sleep quality during long-duration exposure to digital screens and other sources of high-energy blue light. Healthy subjects with 6 or more hours per day of screen time exposure were supplemented with Lutemax 2020 (20mg L/4mg Zi) or a placebo. Macular pigment optical density (MPOD), markers of visual performance, physical indicators of long screen time and sleep quality were assessed. At the end of six months, overall sleep quality was improved in the group taking Lutemax 2020. Additionally, MPOD, contrast sensitivity, disability glare and photo-stress recovery significantly increased and headache frequency, eye strain and eye fatigue significantly decreased in the Lutemax 2020 group. This significance of supplementation with Lutemax 2020 on sleep quality was unique with a significant improvement in overall sleep quality beginning at three months and continuing through the end of the study.

The Next Big Market Opportunity in Restful Sleep

Natural solutions for sleeplessness is a $500 million industry and has grown approximately 13% since 2014. The statistics on sleeplessness and associated disorders may explain the increased demand for natural sleep solutions. According to the American Sleep Association, 50-70 million adults have difficulty sleeping, which has repercussions during waking hours. The B.L.U.E. Study demonstrates, for the first time, that supplementing with the three macular carotenoids as found in Lutemax 2020 has applications for today's consumer by addressing the growing concerns of excessive screen time and exposure to high-energy blue light and their impact on visual performance as well as sleep quality.



ABOUT LUTEMAX 2020

Award-winning, globally-recognized Lutemax 2020 is a naturally-derived marigold extract providing all three macular carotenoids (lutein and enhanced levels of both zeaxanthin isomers—RR-and RS [meso]-zeaxanthin) at the same 5:1 ratio as found in nature. FDA-GRAS notified Lutemax 2020 is manufactured under a fully vertically integrated source. For more information, visit omniactives.com.

SPONSORED BY

OmniActive Health Technologies (www.omniactives.com) offers a range of quality ingredients that are innovative and scientifically validated to address complex challenges for customers in the dietary supplement, food and beverage space using technology-driven, sustainable solutions with application support within a global regulatory framework. OmniActive's core products include carotenoids, plant extracts and specialty functional ingredients. The company develops IP-protected, science-backed branded ingredients from natural sources using cutting edge technologies. OmniActive leverages international R&D strengths to deploy an array of state of the art manufacturing technologies in extraction, purification, isolation and delivery of nutritional actives. Clinical research geared towards demonstrating efficacy and claim substantiation is the cornerstone of OmniActive's R&D activities. The company's centers of excellence are located in North America and India, whereas its cGMP and HACCP system-compliant manufacturing operations are located at multiple FDA inspected sites in India. Whether looking for a new ingredient to add to a finished product, or technology to enhance an existing ingredient, OmniActive delivers unmatched innovation.

Lutein For Every Age™: Early and consistent lutein intake may help maintain healthy eyes of all ages. Lutein For Every Age™ is an award-winning, educational campaign created by OmniActive Health Technologies to raise awareness of the benefits of early and consistent lutein intake to maintain proper eye, skin, cognitive and general health throughout a lifetime. For more information, visit LuteinForEveryAge.org.

What's You're B.L.U.E.?™: What's Your B.L.U.E.?™ (Blue Light User Exposure) is an exciting new initiative based on scientific research and OmniActive's clinical studies to spread awareness on high-energy blue light exposure, its sources and ways to help protect the eyes from its effects with the support of the macular carotenoids. For more information, visit whatsyourblue.info.

FOR INDUSTRY PURPOSES ONLY.

Lutemax 2020 and OmniBead are trademarks of OmniActive Health Technologies Ltd.

These statements have not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure, or prevent and disease.

REFERENCES

1. The 2013 GALLUP Study of U.S. Eye Health - - Basic Survey. Multisponsor Surveys, Inc.
2. Gutnick AL, et al., Always Connected: The New Digital Media Habits of Young Children (2011).
3. Zero to Eight: Children's Media Use in America 2013.
4. GFK. (2014). Teen's Time Spent Online Grew 37% Since 2012, Outpacing Other Age Groups [press release]. Retrieved from http://www.gfk.com/us/news-and-events/press-room/press-releases/documents/1-16-14-teen-internet.pdf.
5. eMarketer 2014.
6. Dscout 2016. Putting a Finger on Our Phone Obsession. Mobile touches: a study on humans and their tech. Available at: https://blog.dscout.com/mobile-touches.
7. Financial Times. Screen use can affect your eye health in digital age. Available at: https://www.ft.com/content/435eef82-654e-11e6-8310-ecf0bddad227.
8. Common Sense Media. The Common Sense Census: Media Use by Tweens and Teens. Available at: https://www.commonsensemedia.org/research/the-common-sense-census-media-use-by-tweens-and-teens
9. The Nielsen Total Audience Report, Q1 2016. Available online: www.nielsen.com/us/en/insights/reports/2016/the-total-audience-report-q1-2016.html (accessed on 10 April 2017).
10. Travers PH and Stanton BA. Office workers & video display terminals: physical, psychological & ergonomic factors. AAOHN j. (2002) 50: 489-93.
11. Himebaugh NL, et al., Blinking and tear break-up during four visual tasks. Optometry & Vision Sci. (2009) Feb 1;86(2):E106-14.
12. Gupta N, et al. Computer vision syndrome: prevalence and predictors among college staff and students. J Dental Med Sci. (2016) 15; 9: 28-31.
13. Logaraj M, Madhupriya V, and Hegde SK. Computer Vision Syndrome and Associated Factors Among Medical and Engineering Students in Chennai. Ann Med Health Sci Res. (2014) Mar-Apr; 4(2): 179–185.
14. LeGates TA, et al., Light as a central modulator of circadian rhythms, sleep and affect. Nat Rev Neurosci (2014) 15(7):443–454.
15. Golombek DA, Rosenstein RE. Physiology of circadian entrainment. Physiol Rev (2010) 90(3):1063–1102.
16. LeGates TA, et al., Light as a central modulator of circadian rhythms, sleep and affect. Nat Rev Neurosci (2014) 15(7):443–454.
17. Cao D and Barrionuevo PA, The importance of intrinsically photosensitive retinal ganglion cells and implications for lighting design. J Solid State Light. (2015) 2:10. Available at: https://doi.org/10.1186/s40539-015-0030-0.
18. Lockley SW, et al., High sensitivity of the human circadian melatonin rhythm to resetting by short wavelength light. J Clin Endo Metab. (2003) 88 (9): 4502–5.
19. Gianluca Tosini, et al. Effects of blue light on the circadian system and eye physiology. Mol Vis. 2016; 22: 61–72.
20. Chang AM, et al., Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next-morning alertness. Proc Natl Acad Sci U S A. (2015) 112:1232–1237
21. Condition Management and Opportunities for Supplement Use. NMI Nutritional Supplements Report Series: Volume 4. 2016.
22. Supplement Business Report. Nutrition Business Journal. 2015.
23. Sleep and Sleep Disorder Statistics. American Sleep Association. Available at: https://www.sleepassociation.org/sleep/sleep-statistics/
24. Stringham JM, et al., Macular Carotenoid Supplementation Improves Visual Performance, Sleep Quality, and Adverse Physical Symptoms in Those with High Screen Time Exposure. Foods. (2017) 6, 47; doi:10.3390/foods6070047.
25. Wood, B, et al., Light level and duration of exposure determine the impact of self-luminous tablets on melatonin suppression. App Ergon. (2012) http://dx.doi.org/10.1016/j.apergo.2012.07.008
26. Cao, D. and P. A. Barrionuevo (2015). The importance of intrinsically photosensitive retinal ganglion cells and implications for lighting design. J Solid State Light (2015) 2(1): 10.
27. Rasmussen, H. M., et al. Lutein, zeaxanthin, meso-zeaxanthin content in egg yolk and their absence in fish and seafood. J Food Comp Anal (2012) 27(2): 139-144.