



## EFFECT OF BLUE LIGHT EXPOSURE FROM DIGITAL DEVICES ON OCULAR SURFACE HEALTH

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### INTRODUCTION

In recent decades, technological advancements have dramatically altered human behavior, particularly with the widespread use of digital devices such as smartphones, tablets, computers, and LED screens. These devices emit blue light, a high-energy visible (HEV) light within the 400–500 nm wavelength range. Blue light, though essential for regulating circadian rhythm and alertness during daytime exposure, has raised concerns due to its increasing exposure during evening and night hours, primarily through prolonged screen time.

Ocular health, particularly the integrity of the ocular surface, is increasingly being compromised by prolonged exposure to blue light. The ocular surface comprises the cornea, conjunctiva, tear film, and associated glands, all of which contribute to eye comfort and vision clarity. Chronic exposure to artificial blue light is believed to induce oxidative stress, inflammation, and tear film instability, thereby contributing to ocular surface disorders such as dry eye disease (DED), photophobia, and eye fatigue. The problem is more pronounced in individuals with high screen time, especially among professionals and students engaging in digital learning or remote work setups.

Given the global trend of increased screen dependency, understanding the impact of blue light exposure on the ocular surface is of pressing importance. This study aims to explore the relationship between digital blue light exposure and ocular surface health, thereby providing insights for preventive and therapeutic strategies to mitigate digital eye strain and associated conditions.

#### Need of Study

There is a growing need to assess blue light's impact on ocular surface health due to increased screen time, rising dry eye cases, and limited awareness of blue light-induced ocular damage.

### METHODOLOGY

Blue light is emitted from digital device screens primarily because of the **LED backlighting technology** used in modern displays such as those in smartphones, computers, tablets, and TVs. Here's why:

#### ABOUT BLUE LIGHT

##### 1. LED Backlighting

Most digital screens use **white LEDs** as a light source, which are actually **blue LEDs coated with a yellow phosphor layer**. This combination produces a bright white light, but a significant portion of it is still in the blue wavelength range (around 400–500 nm).

##### 2. High Brightness and Clarity

Blue light has **shorter wavelengths and higher energy**, which helps improve image clarity and brightness. This makes the display more vibrant and readable, especially in well-lit environments.

##### 3. Color Rendering

Digital screens use **RGB (Red, Green, Blue)** subpixels to produce all the colors seen on the display. The **blue subpixel** is essential for rendering a full spectrum of colors, making it a necessary component in screen design.

##### 4. Energy Efficiency

Blue LEDs are more **energy-efficient** and longer-lasting than older technologies like CCFL (cold cathode

fluorescent lamps), which is why manufacturers prefer them.

## IMPACT ON EYE HEALTH

### 1. Excessive Screen Time (Blue Light Exposure)

Prolonged use of digital devices leads to a condition commonly known as **Digital Eye Strain (DES)** or **Computer Vision Syndrome (CVS)**. One of the main contributors is **blue light**, a high-energy visible light emitted by screens.

#### Effects

- **Reduced blink rate:** Normally we blink 15–20 times per minute, but screen use reduces this by up to 60%, causing **tear evaporation and dry eye symptoms**.
- **Blue light exposure:** Continuous exposure may disrupt the **circadian rhythm**, leading to poor sleep quality, and possibly cause **oxidative stress** on ocular surface cells.
- **Visual fatigue:** Constant focusing on digital screens stresses the ciliary muscles, resulting in eye fatigue, blurred vision, and headaches.

### 2. Poor Lighting or Posture

Improper lighting conditions and poor posture can exacerbate eye discomfort during reading, writing, or screen use.

#### Effects

- **Glare and contrast issues:** Too much or too little light causes the eyes to strain to adapt, leading to headaches, squinting, and tired eyes.
- **Incorrect posture:** Viewing screens at an awkward angle or distance affects **visual accommodation**, increasing the effort required by the eyes to focus.
- **Neck and shoulder strain** from bad posture can indirectly lead to tension headaches and eye discomfort.

### 3. Inadequate Blinking or Hydration

Blinking is a natural mechanism that spreads tears across the eye surface, maintaining lubrication and clearing debris.

#### Effects

- **Decreased blinking** during screen use causes **tear film instability**, contributing to **dry eye syndrome**.
- **Inadequate hydration** affects tear production, resulting in **grittiness, burning, and redness** of the eyes.
- **Chronic dry eye** can lead to inflammation, increased susceptibility to infection, and even damage to the corneal surface.

## EFFECTS OF BLUE LIGHT ON OCULAR SURFACE

Blue light, particularly in the 400–500 nm wavelength range, is a high-energy visible (HEV) light emitted by most digital devices, LED lights, and modern lighting

systems. While exposure to natural blue light from the sun is essential for regulating biological processes, prolonged and artificial exposure—especially from screens—can adversely affect the **ocular surface** and overall **visual comfort**. Here are the key mechanisms by which blue light impacts the ocular surface:

### 1. Disruption of Circadian Rhythm (Sleep Issues)

Blue light plays a vital role in regulating the **circadian rhythm** by influencing **melatonin** secretion, a hormone that governs sleep-wake cycles.

#### Impact on Eye Health

- Exposure to blue light, especially during evening or nighttime screen use, **suppresses melatonin production**, delaying sleep onset.
- Poor sleep quality contributes to **ocular surface fatigue** and worsens symptoms of dry eye disease.
- Inadequate rest can impair the **regeneration of ocular tissues**, leading to longer recovery from daily visual stress and potential inflammation.

### 2. Potential Oxidative Stress on Ocular Cells

Blue light has higher energy than other visible light, and excessive exposure can lead to **oxidative stress** by generating **reactive oxygen species (ROS)** in ocular tissues.

#### Effects

- ROS can damage **epithelial cells of the cornea and conjunctiva**, essential components of the ocular surface.
- This may lead to **cell apoptosis (programmed cell death)**, contributing to chronic eye irritation and discomfort.
- Oxidative damage weakens the protective barrier of the ocular surface, increasing vulnerability to **environmental insults and allergens**.

### 3. Tear Film Instability and Inflammation

The tear film is a critical protective layer that maintains moisture and clarity on the eye's surface. Blue light exposure can disturb its composition and stability.

#### Effects

- **Reduced blinking** during screen use (often associated with blue light exposure) leads to **tear evaporation**, weakening the tear film.
- This instability triggers **ocular surface inflammation**, leading to symptoms like burning, stinging, foreign body sensation, and blurred vision.
- Chronic tear film disruption can result in **dry eye disease (DED)**, with increased osmolarity and inflammatory cytokine release on the ocular surface.

## PREVENTIVE MEASURES FOR OCULAR SURFACE HEALTH

With the increasing dependency on digital devices, taking proactive steps to safeguard eye health is crucial. Several **lifestyle adjustments and nutritional**

**interventions** can significantly reduce the risk of digital eye strain, dry eye disease, and other ocular issues. Below are key preventive strategies:

### 1. 20-20-20 Rule

This simple yet effective technique helps reduce eye fatigue during prolonged screen use:

- **Every 20 minutes**, take a **20-second break** and look at something **20 feet away**.
- It helps **relax eye muscles**, encourages **blinking**, and maintains **tear film stability**.

### 2. Blue Light Filters/Glasses

- Use of **blue light filtering glasses** or **screen protectors** can help block high-energy visible (HEV) blue light.
- This reduces glare, minimizes **retinal stress**, and helps maintain **circadian rhythm balance**, especially during evening screen exposure.

### 3. Screen Settings (Brightness, Night Mode)

- Adjust **brightness and contrast** to match ambient lighting to reduce strain.
- Enable **“Night Shift”** or **“Night Mode”** settings to reduce blue light emission and shift screen colors toward warmer tones in the evening.
- Maintain proper **font size and screen resolution** for comfortable reading.

### 4. Proper Ergonomics and Lighting

- Position the screen at **eye level or slightly below**, about **20–24 inches away** from the eyes.
- Use **anti-glare screens** and ensure room lighting does not reflect off the screen.
- Good posture and screen alignment reduce **neck strain** and indirectly prevent visual fatigue.

## NUTRITION AND EYE HEALTH

Proper nutrition plays a fundamental role in maintaining ocular surface integrity and protecting against oxidative stress.

### Key Nutrients

- **Vitamin A**: Essential for the maintenance of the **conjunctival membranes** and **corneal epithelium**.
- **Vitamins C and E**: Powerful **antioxidants** that protect ocular tissues from oxidative damage.
- **Omega-3 fatty acids**: Help in **tear production** and reduce inflammation in **dry eye disease**.
- **Lutein and Zeaxanthin**: Carotenoids concentrated in the **macula** that filter harmful blue light and protect retinal cells.
- **Hydration**: Adequate water intake is vital for **tear film stability** and preventing dry eyes.

## REGULAR EYE CHECK-UPS

### Importance

- Routine **comprehensive eye exams** can detect early signs of eye strain, dry eye syndrome, refractive

errors, or more serious conditions like glaucoma or macular degeneration.

- Eye exams are crucial even in the absence of symptoms, as many ocular conditions are **initially asymptomatic**.

### Recommendations

- Adults should undergo an eye exam **at least once every 1–2 years**.
- Individuals with chronic conditions (e.g., diabetes, hypertension) or high digital exposure may require **more frequent monitoring**.

## Ayurvedic Solutions for Ocular Surface Health in the Digital Age

Ayurveda emphasizes holistic well-being and offers time-tested remedies to maintain and restore **netra swasthya (eye health)**. The ancient texts recognize the eyes as a **Pitta-dominant organ**, vulnerable to heat, dryness, and light exposure—conditions worsened by modern digital device usage. The symptoms of digital eye strain closely resemble **Abhishyanda (ocular inflammation)**, **Shushkakshipaka (dry eye syndrome)**, and **Drishtidaurbalya (visual fatigue)** as described in Ayurvedic classics.

Below are key Ayurvedic strategies to counteract the impact of **blue light and digital strain**:

### 1. Netra Tarpana (Rejuvenating Eye Therapy)

A specialized **oleation therapy**, where **medicated ghee** (such as Triphala Ghrita or Jeevantyadi Ghrita) is retained in a dough boundary around the eyes.

- **Benefits**: Nourishes ocular tissues, relieves dryness, fatigue, and irritation.
- **Recommended for**: People with excessive screen use and dry eye symptoms.

### 2. Anjana (Collyrium Application)

Application of herbal eye salves like **Saptamrita Lauh**, **Sauviranjana**, or **Triphala-based Anjana**.

- **Benefits**: Clears Kapha and Pitta dosha from the eye, enhances clarity, and prevents infections.
- **Daily application of Rasanjana with honey** (as advised in Dinacharya) helps keep eyes clear and refreshed.

### 3. Triphala Eye Wash (Triphala Kashaya Parisheka)

Triphala (Amalaki, Haritaki, Bibhitaki) is renowned for its **Chakshushya (eye-nourishing)** properties.

- **Method**: Use cooled decoction of Triphala for **eye irrigation or wash**, especially after long screen exposure.
- **Benefits**: Reduces strain, improves tear film quality, and soothes inflammation.

### 4. Ayurvedic Oral Formulations

Certain classical medicines help strengthen vision and reduce oxidative stress:

- **Triphala Ghrita** – Internal use for chronic dry eye and eye fatigue.

- **Saptamrita Lauh** – Useful in visual weakness and strain.
- **Punarnavadi Kwath** – Acts as an anti-inflammatory for systemic and ocular health.
- **Amalaki Rasayana** – Rich in Vitamin C and antioxidants; rejuvenates eye tissues.

#### 5. Diet and Lifestyle Modifications

- **Include eye-friendly foods:** Green leafy vegetables, ghee, Amla, carrots, and soaked almonds.
- Avoid excessive spicy, salty, and fried foods that aggravate Pitta.
- **Follow Dinacharya:** Splashing cold water on the eyes in the morning and regular blinking helps balance ocular function.

#### 6. Yoga and Eye Exercises

- **Trataka:** A meditative gazing practice that improves focus and ocular strength.
- **Palming and blinking** exercises help relax eye muscles and stimulate tear production.

### DISCUSSION

The increasing use of digital devices in daily life has significantly raised concerns about the harmful effects of prolonged blue light exposure on ocular surface health. The emitted high-energy visible (HEV) blue light (400–500 nm) from screens can disrupt the homeostasis of the ocular surface by inducing oxidative stress, tear film instability, and low-grade chronic inflammation. These changes manifest clinically as dry eye symptoms, visual fatigue, foreign body sensation, blurry vision, and eye strain, which are hallmarks of Digital Eye Strain (DES).

Research highlights that reduced blinking frequency, poor screen ergonomics, and inadequate hydration further aggravate tear film instability and ocular surface dryness. Additionally, blue light's interference with the circadian rhythm results in sleep disturbances, indirectly impairing ocular recovery and health. Environmental pollutants and modern lifestyle factors also compound these effects, making ocular complaints increasingly common, especially in younger populations.

Preventive strategies like the 20-20-20 rule, use of blue light filtering glasses, proper screen settings, and ergonomic adjustments have shown promise in reducing symptoms. Nutrition also plays a key role in maintaining ocular health—antioxidants like vitamins A, C, E, along with omega-3 fatty acids, lutein, and zeaxanthin are particularly beneficial for retinal and tear film integrity. Furthermore, Ayurvedic practices such as Triphala eye wash, Netra Tarpana, and Rasayana therapy offer a holistic and natural approach to support long-term eye health.

### CONCLUSION

Blue light exposure from digital devices has become an unavoidable component of modern life, significantly affecting ocular surface health. Prolonged screen time

leads to dry eye disease, visual discomfort, and circadian rhythm disturbances, all of which compromise the quality of life and productivity.

However, with timely preventive strategies—such as proper screen use habits, ergonomic adjustments, nutritional support, and integration of traditional Ayurvedic eye care—the adverse effects of blue light can be effectively managed. A combination of modern eye hygiene and classical Ayurvedic interventions provides a comprehensive, sustainable approach to maintain netra swasthya (eye health) in the digital era.

Public awareness, routine eye examinations, and interdisciplinary collaboration between modern ophthalmology and Ayurveda can play a crucial role in preventing and managing digital eye strain, ensuring healthier vision for future generations.