

CURRENT SCENARIO IN THE DEVELOPMENT OF DIGITAL EYE STRAIN AND PREVENTIVE MEASURES – A NARRATIVE REVIEW

Indrapriyadharsini.B^{1*}, Aryasree P P², Oviya K³, Manindar Nathan U⁴, Pavithra R⁵, Harini R⁶, Krishnaveni J⁷

¹ Assistant Professor, Krishna Institute of Optometry and Research, Elayampalayam.

Email: धारशु5555@gmail.com, (Orcid ID: 0009-0002-6183-8088)

² Assistant Professor, Krishna Institute of Optometry and Research, Elayampalayam.

Email: आर्याआगरवाल94@gmail.com, (Orcid ID: 0009-0003-7523-7678)

³ Lecturer, Krishna Institute of Optometry and Research, Elayampalayam

Email: ओवियाओप्टोम@gmail.com (Orcid ID: 0009-0005-1693-7257)

⁴ Lecturer, Krishna Institute of Optometry and Research, Elayampalayam

Email: मानिंदार1947@gmail.com (Orcid ID: 0009-0009-3567-4412)

⁵ Intern B.Sc., Optometry, Krishna Institute of Optometry and Research, Elayampalayam

Email: पवित्रा19042006@gmail.com (Orcid ID: 0009-0004-6921-8574)

⁶ Intern B.Sc. Optometry, Krishna Institute of Optometry and Research, Elayampalayam

Email: अमुहारिनी272@gmail.com (Orcid ID: 0009-0001-5384-8641)

⁷ Intern B.Sc. Optometry, Krishna Institute of Optometry and Research, Elayampalayam

Email: ज.क्रिष्णवेनिकाला2006@gmail.com (Orcid ID: 0009-0003-6054-7227)

***Corresponding author: धारशु5555@gmail.com**

ABSTRACT

The digital revolution has profoundly transformed modern lifestyles, with computers, smartphones, tablets, and other visual display devices becoming indispensable tools for education, occupation, and social interaction. While these technologies offer significant benefits, their prolonged and excessive use has resulted in growing prevalence of digital eye strain also known as computer vision syndrome. Digital eye strain represents a spectrum of visual and extra-ocular symptoms that arise due to sustained viewing of digital screens and emerged as a major public health concern affecting children, adolescents, and adults alike. This article aims to review and synthesize existing evidence on eye health in the digital generation, with particular emphasis on the causes, clinical manifestations, complications, and prevention of digital eye strain. Digital eye strain is a multifactorial condition influenced by prolonged near work, reduced blink rate, increased accommodative and vergence demand, uncorrected refractive errors, poor workplace ergonomics, and prolonged exposure to blue light emitted from digital screens. Commonly reported symptoms include eye fatigue, dryness, irritation, burning sensation, blurred or fluctuating vision, headache, neck, and shoulder pain. In addition, excessive screen exposure, especially during evening hours, has been associated with circadian rhythm disruption and sleep disturbances due to blue light-mediated suppression of melatonin. Regular visual breaks such as the 20-20-20 rule, conscious blinking, and timely correction of refractive and binocular vision anomalies. Public health initiatives and awareness programs are essential to address the widespread nature of digital eye strain. Global organizations such as the world health organization recognize the importance of preventive eye care in maintaining productivity, educational outcomes, and quality of life.

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INTRODUCTION

The rapid evolution of digital technology has profoundly transformed the way humans live, learn, work, and communicate[2]. Over the past few decades, digital devices such as smartphones, computers, tablets, laptops, and other visual display terminals have become inseparable from daily life.[6] The present era is often referred to as the “digital generation” characterized by constant connectivity, information access, and reliance on screen-based technology.[3][10] While these advancements have brought remarkable improvements in efficiency, education, and global communication, they have also

introduced new and emerging challenges to human health, particularly ocular health. [1]

One of the most significant and increasingly prevalent consequences of excessive digital device usage is digital eye

strain, also known as computer vision syndrome.[2] Eye health plays a crucial role in an individual’s overall well-being, cognitive performance, learning ability, and productivity.[24] Vision is the primary sensory modality through which humans interact with their environment, and modern lifestyles place unprecedented visual demands on eyes.[13] Unlike traditional visual tasks, digital screen viewing involves prolonged near

work, sustained accommodation, continuous convergence, reduced blinking, and exposure to artificial lighting conditions.[12] These factors collectively contribute to visual fatigue and ocular discomfort.[5] As a result, digital eye strain has emerged as a major public health concern affecting individuals across all age groups, occupations, and socioeconomic backgrounds.[5] Digital eye strain is defined as a group of visual and ocular symptoms that result from prolonged use of digital devices.[19]

These symptoms include eyestrain, headache, blurred vision, dryness, burning sensation, redness, irritation, watering, and difficulty in focusing. [1] Musculoskeletal symptoms such as neck pain, shoulder stiffness, and backache frequently coexist due to poor posture and improper ergonomics [10]. Although digital eye strain is not typically associated with permanent vision loss, its persistent and recurrent nature significantly affects quality of life, work efficiency, academic performance, and psychological well-being.[15] With increasing screen dependency, the prevalence and impact of digital eye strain are expected to rise further in the coming years.[3] The digital generation encompasses a wide demographic spectrum, including children, adolescents, working adults, and older individuals.[6] Children and adolescents are now exposed to digital screens at a very early age due to online education, digital learning tools, gaming, and social media engagement.[8][12] Early and excessive screen exposure during critical periods of visual development raises concerns regarding accommodative stress, binocular vision anomalies, dry eye symptoms and the progression of refractive errors such as myopia among school-aged children, particularly in urban populations.[2][13] Among adults, occupational screen exposure is a dominant risk factor for digital eye strain.[4] The modern workplace relies heavily on computers for tasks such as data entry, documentation, programming, design, accounting, and communication.[31] Employees in information technology, finance, healthcare, education and administrative sectors often spend extended hours in front of screens without adequate visual breaks.[25] The transition to remote work and virtual meetings, especially following the COVID-19 pandemic, has further increased daily screen time. Consequently, digital eye strain has become one of the most common issues among users.[10][18]

The pathophysiology of digital eye strain is multifactorial and involves a complex interaction between visual, ocular surface, environmental, and ergonomic factors.[10] Prolonged near work places sustained demands on the accommodative system, leading to accommodative fatigue or spasm.[34] Continuous convergence effort may result in binocular vision stress, manifesting as diplopia or Asthenopia symptoms [15]. Reduced blink rate during screen use disrupts tear film stability, increasing tear evaporation and predisposing individuals to dry eye disease. [3] Environmental conditions such as glare, poor lighting, air conditioning, and improper screen positioning further aggravate ocular discomfort. [31] Digital screens differ significantly from printed text in terms of visual characteristics. Screen-based text is composed of pixels rather than solid characters, resulting in reduced edge contrast and increased visual effort.[10] Glare and reflections from screens, especially in poorly designed workspaces, contribute to visual fatigue.[5] Additionally, digital devices emit blue light within the visible spectrum, which has been implicated in visual discomfort and circadian rhythm disturbances.[7][9]

Although the long-term retinal effects of blue light exposure remain under investigation, its role in contributing to eye strain disruption cannot be ignored. [3] Prevention of digital eye strain is therefore of paramount importance.[9] [6] Unlike many ocular disorders, digital eye strain is largely preventable through simple, cost-effective, and evidence-based interventions.[2] Preventive strategies focus on optimizing visual ergonomics, encouraging healthy visual habits, ensuring appropriate refraction correction, and promoting regular eye examinations.[12] Behavioural modifications such as taking frequent breaks, conscious blinking, maintaining proper viewing distance, and reducing screen glare

can significantly reduce visual discomfort. [1] The widely recommended 20-20-20 rule, looking at an object 20 feet away for 20 seconds every 20 minutes, helps relax the accommodative system and minimize visual fatigue.[15] Workplace and educational interventions play a critical role in digital eye strain prevention.[22] Proper workstation design, appropriate screen height, adequate lighting, and ergonomic seating arrangements are essential components of a visually comfortable environment.[5] In educational settings, incorporating eye health awareness programs for students, teachers, and parents can foster early adoption of healthy screen habits.[21] Limiting recreational screen time, encouraging outdoor activities, and ensuring regular eye check-ups are particularly important for children and adolescents.[8] Eye care professional has a central role in addressing the challenges posed by the digital generation.[18] Optometrists and ophthalmologists are responsible not only for diagnosing and managing digital eye strain but also for educating patients about preventive strategies.[18] Identification and correction of refractive errors, prescription of occupational or computer-specific lenses, management of dry eye disease, and evaluation of binocular vision anomalies are essential aspects of comprehensive care.[13] Public health initiatives aimed at raising awareness about digital eye strain can further strengthen preventive efforts at the community level.[14]

GLOBAL USE OF COMPUTERS AND EXPOSURE TO BLUE RAYS

The rapid expansion of digital technology has led to an unprecedented global increase in the use of computers and other screen-based devices. [18] Computers, laptops, tablets, and smartphones have become essential tools in education, healthcare, business, communication, and entertainment.[6] As societies transition towards digitally driven systems, individuals across all age groups are spending prolonged hours in front of screens.[15] While this digital transformation has improved efficiency and connectivity worldwide, it has also raised concerns regarding prolonged exposure to blue rays, commonly referred to as blue light, emitted from digital screens. [7] Globally, computer usage has increased dramatically over the last two decades. [3]

The integration of digital technology into workplaces, educational institutions, and homes has resulted in extended daily screen time.[5] According to international reports, billions of people worldwide now rely on computers for occupational tasks, online learning, information access, and social interaction.[19] The COVID-19 pandemic further accelerated this trend, with remote working, virtual classrooms, telemedicine, and online services becoming routine.[10] As a result, average daily screen exposure has significantly increased, often exceeding recommended limits for safe visual use.[7] Blue light is a component of the visible light spectrum with a short wavelength (approximately 400-500nm) and high energy.[16] Natural blue light is present in sunlight and plays an important role in regulating circadian rhythm, alertness, mood, and cognitive performance.[9] However, artificial sources of blue light, such as light-emitting diode screens used in computers and smartphones, emit blue light continuously and at close viewing distances.[3] Unlike natural exposure, which varies with time of day and environmental conditions, digital screen exposure is often prolonged and intense and occurs during late evening or nighttime hours.[25] The increasing global dependence on computers has significantly increased cumulative blue light exposure. [8] Modern screens use LED backlighting, which emits a substantial proportion of blue light to enhance brightness and image clarity.[7] Prolonged viewing of computer screens requires sustained near focus, reduced blink rate, and continuous exposure to blue light, all of which contribute to visual discomfort and digital eye strain.[34] One of the most widely discussed effects of blue light exposure from computers is its role in digital eye strain. [2] Blue light scatters more than longer wavelengths, reducing contrast and increasing visual effort. [17] This scattering effect can contribute to symptoms such as eye fatigue, blurred vision, headache, and difficulty in focusing.[1][3]

Another important concern related to blue light exposure is its effect on circadian rhythm and sleep patterns. [5] Blue light plays a key role in suppressing melatonin secretion, a hormone responsible for regulating sleep-wake cycles.[8]

The issue is particularly relevant among students and working professionals who engage in late-night screen use for academic or occupational purposes. [9] Chronic sleep disruption has broader implications for mental health, cognitive performance, and overall well-being.[7] The global impact of blue light exposure is particularly significant among children and adolescents. [13] Early and prolonged exposure to computers for online education, gaming, and recreational activities has become increasingly common.[26][27] Developing visual excessive screen time has been associated with increased visual fatigue and myopia progression. [8] Reduced outdoor activity combined with extended near work further compounds the risk to visual health. [2] Promoting balanced screen use and outdoor exposure is therefore essential for safeguarding eye health in younger populations. [32] From a public health perspective, the rising global use of computers and associated blue light exposure necessitates preventive strategies and awareness programs.[10]

Organizations such as the World Health Organization emphasize the importance of eye health as a determinant of productivity, learning ability, and quality of life.[13] Education regarding safe screen habits, appropriate viewing duration, ergonomic practices, and regular eye examinations is crucial to reduce the burden of digital eye strain.[28] Technological interventions such as screen filters, night mode settings, and blue light-filtering lenses may provide symptomatic relief for some users, although they should be considered as part of a comprehensive preventive approach rather than a standalone solution.[15]

CLINICAL SYMPTOMS OF EYE STRAIN AND COMPLICATIONS OF BLUE RAY EXPOSURE

The increasing reliance on digital devices has led to a significant rise in eye-related complaints worldwide.[12] Prolonged use of computers, smartphones, and tablets places excessive demand on the visual system, resulting in a condition commonly referred to as digital eye strain or computer vision syndrome.[6] In addition to visual fatigue caused by sustained near work.[4] Continuous exposure to blue rays emitted from digital screens has been recognized as a contributing factor to ocular discomfort and associated complications.[29][30] Understanding the clinical symptoms of eye strain and the potential complications related to blue ray exposure is essential for early identification, prevention, and effective management.[9][21] Clinical symptoms of eye strain associated with digital device use present with a wide spectrum of symptoms that can be broadly categorized into visual symptoms, ocular surface symptoms, and extraocular or musculoskeletal symptoms.[10] Visual symptoms are among the most commonly reported manifestations of digital eye strain.[9] These include blurred vision, difficulty in focusing, intermittent diplopia, and reduced visual clarity, especially after prolonged screen use. [13]

Many individuals experience transient myopia or accommodative spasm due to sustained near focusing demands. [7] Visual fatigue often worsens toward the end of the day and may temporarily improve after a reset, highlighting its functional rather than structural nature. [31][32] Ocular surface symptoms primarily result from reduced blink rate during screen use. [33] Studies have shown that blink frequency may decrease by up to 50% when viewing digital screens, leading to increased tear film evaporation and instability. [18] As a result, individuals commonly report symptoms such as dryness, burning sensation, irritation, foreign body sensation, watering, and itching of the eyes. [34] [9] These symptoms are particularly pronounced in air-conditioned environments and among contact lens users.[6] Extraocular and musculoskeletal symptoms frequently accompany visual complaints. [27] Headaches are one of the most prevalent symptoms of eye strain and are often frontal or periocular location. [5] Neck pain, shoulder stiffness, and upper back discomfort arise due to poor posture, improper screen

positioning, and prolonged static sitting. [2] These symptoms indicate the close relationship between visual ergonomics and overall physical comfort during digital device use.[15]

Although eye strain symptoms are usually temporary, their persistent recurrence can significantly impair work efficiency, academic performance, and quality of life. [5] If left unaddressed, chronic eye strain may contribute to the development or worsening of underlying binocular vision disorders, dry eye disease, and refractive stress. [19] Role of blue ray exposure in eye strain: Blue rays, also known as blue light, are short-wavelength, high-energy visible light in the range of approximately 400-500nm. [3] Digital screens that use LED backlighting emit a considerable amount of blue light to enhance brightness and image sharpness. [28] Blue light scatters more within the eye compared to longer wavelengths, reducing image contrast and increasing visual effort. [9] This scattering effect contributes to visual discomfort and fatigue, particularly during prolonged screen exposure. [7] Exposure to blue rays does not act independently but rather exacerbates eye strain when combined with other factors such as prolonged viewing duration, improper lighting, glare, and uncorrected refractive errors.[12] While blue light from digital screens is less intense than sunlight, the cumulative effect of long-term exposure at close viewing distances is a growing concern in the digital era.[12][15] Complications of blue ray exposure one of the most significant complications associated with blue ray exposure is disruption of circadian rhythm. [9] Blue light plays a key role in regulating the body's internal clock by suppressing melatonin secretion. [8] Excessive exposure to screens during evening or nighttime hours can delay melatonin release, leading to difficulty in falling asleep, reduced sleep quality, and altered sleep-wake cycles. [7]

Chronic sleep disturbances can indirectly affect ocular health by increasing fatigue, reducing tear production, and exacerbating symptoms of eye strain. [8] Dry eye disease is another important complication linked to prolonged screen use and blue light exposure. [10] Reduced blink rate and increased tear evaporation contribute to chronic ocular surface inflammation. [19] Over time, this may progress from episodic discomfort to persistent dry eye symptoms, requiring medical management. [14] Individuals with pre-existing dry eye disease are particularly susceptible to worsening symptoms during extended screen exposure. [13] There has also been considerable discussion regarding the potential retinal effects of blue light exposure. [7] Experimental studies have demonstrated that high-intensity blue light can cause photochemical damage to retinal cells under laboratory conditions. [3]

This has raised concerns about a possible association between cumulative blue light exposure and retinal disorders such as age-related macular degeneration. [29] However, current clinical evidence suggests that blue light emitted from digital screens is well below levels known to cause direct retinal damage. [7] Another indirect complication of chronic eye strain and blue ray exposure is the worsening of binocular vision anomalies. [27] Sustained convergence and accommodation demands can unmask or exacerbate conditions such as convergence insufficiency and accommodative dysfunction. [32] These conditions may present with persistent headaches, eye pain, and reading difficulties, especially among students and office workers. [12] From a public health perspective, the widespread prevalence of eye strain and blue light-related complications has significant implications. [18] According to the World Health Organization, visual health is a critical determinant of educational achievement, work productivity, and overall quality of life. Failure to address modifiable risk factors such as excessive screen exposure may contribute to a growing burden of visual discomfort and associated health issues worldwide.[21]

TREATMENTS FOR SPECIFIC SYMPTOMS

Digital eye strain also known as computer vision syndrome, is a multifactorial condition resulting from prolonged use of digital devices such as computers, smart phones, and tablets. [2] The condition presents with a wide range of symptoms affecting the

visual system, ocular surface, and musculoskeletal structures. [13] Since the manifestations of digital eye strain vary among individuals, treatment should be symptom-specific, individualized, and preventive in nature. [2] Effective management requires a combination of optical correction, ocular surface management, ergonomic modifications, behavioural changes, and patient education. [34] Treatment of blurred vision and reduced visual acuity blurred vision during or after prolonged screen use is commonly caused by accommodative fatigue, accommodative spasm, or uncorrected refractive errors. [1][31]

The primary step in management is a comprehensive eye examination to detect refractive errors such as myopia, hypermetropia, astigmatism, or presbyopia. [23] Accurate spectacle correction significantly reduces visual stress and improves clarity during near and intermediate tasks. [33][34] For individuals who spend long hours working on computers, occupational or computer-specific lenses are often recommended. [5] These lenses are designed to provide optimal focus at intermediate viewing distances, thereby reducing accommodative demand. [26] In presbyopic patients, progressive addition lenses or office lenses may be prescribed to improve comfort during screen work. [12] Regular visual breaks and adherence to the 20-20-20 rule help prevent accommodative overuse and reduce symptoms of visual fatigue. [15] Treatment of difficulty in focusing and accommodative stress in sustaining focus is frequently associated with accommodative dysfunction. [3] Prolonged near work places continuous strain on accommodative system, leading to symptoms such as fluctuating vision, eye strain, and headache. [8] Management includes reducing continuous near work duration through scheduled breaks and alternating visual tasks. [12][13] In patients diagnosed with accommodative insufficiency or accommodative spasm, vision therapy exercises may be prescribed to improve accommodative flexibility and endurance. [18]

Proper lighting, increased font size, and maintaining an appropriate viewing distance (50-70 cm) also reduce accommodative demand. [16] Early correction of refractive errors plays a critical role in preventing chronic accommodative stress. [32] Treatment of eye fatigue and asthenopia, also known as asthenopia, is one of the hallmark symptoms of digital eye strain. [6] It results from prolonged visual concentration glare, reduced contrast, and continuous screen exposure. [9] Treatment focuses on reducing visual load by optimizing workstation ergonomics and screen settings. Anti-glare filters may be useful in environments where reflections cannot be adequately controlled. [15] In individuals, blue light-filtering lenses may provide subjective relief from visual discomfort, although they should be considered supportive rather than primary treatment. [13] Ocular surface symptoms such as dryness, burning sensation, irritation, and foreign body sensation are among the most common complaints associated with digital eye strain. Reduced blink rate during screen use leads to tear film instability and increased evaporation. [11] The mainstay of treatment is the use of lubricating eye drops, preferably preservative-free artificial tears. [12] Patients should be educated about conscious and complete blinking, particularly during prolonged screen tasks. [24] Environmental modifications such as conditioning exposure, avoiding direct airflow to the face, and using humidifier help maintain tear film stability. [33] In moderate to severe cases, gel formulations, lipid-based tear supplements, or treatment of underlying meibomian gland dysfunction may be required under professional supervision. [11][14]

Treatment of headache associated with digital eye strain is often frontal or periorbital and is commonly linked to uncorrected refractive errors, binocular vision anomalies, or poor posture. [18] Treatment begins with accurate refractive correction and evaluation of binocular vision status. [7] Patients with convergence insufficiency or decompensated heterophoria may benefit from vision therapy or prism correction. [15] Ergonomic modifications such as proper screen height, chair support, and keyboard placement help reduce postural strain contributing to headaches. [5] [2] Treatment of neck, shoulder and back pain:

musculoskeletal symptoms frequently coexist with visual complaints in digital eye strain. [10] Neck pain, shoulder stiffness, and upper back discomfort are usually caused by poor posture, improper workstation design, and visual strain leading to compensatory body movements. [18] Management focuses on ergonomics correction, including adjustable chairs with lumbar support, appropriate desk height, and screen positioning slightly below eye level. [19] Patients should be encouraged to maintain an upright posture with relaxed shoulders. [5] Periodic stretching exercises and short movement breaks during screen use help reduce muscle stiffness and improve circulation. [2][10]

PREVENTION OF EYE STRAIN

With the rapid expansion of digital technology, prolonged use of computers, smartphones, and other screen-based devices has become unavoidable in daily life. [2] As a result, digital eye strain, also known as computer vision syndrome, has emerged as one of the most common visual complaints worldwide. [3] Although digital eye strain does not usually cause permanent visual damage, its high prevalence and recurrent nature significantly affect visual comfort, work efficiency, academic performance, and quality of life. [1] Importantly, digital eye strain is largely preventable through appropriate behavioural, ergonomic, and clinical interventions. [15] Effective prevention strategies focus on reducing visual stress, maintaining ocular surface health, and promoting healthy screen habits. [19] Ergonomic interventions: proper ergonomics play a fundamental role in the prevention of eye strain. [5] The computer screen should be positioned at an appropriate distance, generally between 50 and 70 cm from the eyes, and below eye level to reduce accommodative and posture stress. [22] Screen height that is too high or too low can force abnormal head and neck posture, indirectly contributing to visual fatigue and musculoskeletal discomfort. Light conditions should be optimized to minimize glare and reflections on the screen. [25] Visual breaks and work-rest scheduling continuous near work is a major contributor to eye strain. [3] One of the most effective preventive strategies is the incorporation of regular visual breaks during screen use. [34] The widely recommended 20-20-20 rule advises individuals to look at an object at least 20 feet away for 20 seconds every 20 minutes. [13]

This practice relaxes the accommodative system, reduces visual fatigue, and improves comfort during prolonged screen tasks. [24] Blinking awareness and ocular protection reduced blink rate during screen viewing key factor in the development of dry eye symptoms and ocular discomfort. [17] Studies have shown that individuals blink less frequently and incompletely while focusing on digital screens, leading to tear film instability and increased evaporation. Preventive strategies include conscious blinking, especially during prolonged screen use. [16] Users should be encouraged to blink fully and frequently to maintain tear film stability and reduce evaporation. [11] Optimization of screen settings and devices use adjusting digital device settings is a simple yet effective preventive measure. [32] Increasing font size, enhancing text contrast, and reducing screen glare improve readability and reduce visual effort. [19] High-resolution screens without good refresh rates provide clearer images and reduce visual fatigue. [3]

Prevention of blue light-related effects exposure to blue light from digital screens, especially during evening and nighttime hours, has been associated with visual discomfort and disruption of circadian rhythm. [4] Preventive strategies include limiting screen use at least one to two hours before bedtime. [6] Activating night-mode or blue-light-reduction settings on devices may reduce short-wavelength light exposure. [8] Eye care professional plays a vital role in preventing digital eye strain through early diagnosis, patient education, and individualized management. [28] Counselling patients about healthy screen habits, ergonomic practices, and the importance of regular eye examinations is essential. [20] From a public health perspective, Organization such as the world health Organization emphasize the preventive eye care is crucial for maintaining productivity,

educational performance, and quality of life in an increasingly digital world.[15][21]

CONCLUSION

The widespread use of digital devices has become an integral part of modern life, significantly influencing education, work, and daily communication. However, prolonged exposure to computers and other digital screens has led to a growing prevalence of digital eye strain, making eye health an important concern for the digital generation. Symptoms such as eye fatigue, dryness, blurred vision, headache, and musculoskeletal discomfort are commonly reported and can adversely affect visual comfort, productivity, and overall quality of life. Digital eye strain is a multifactorial and largely preventable condition. Contributing factors include sustained near work, reduced blink rate, improper ergonomics, uncorrected refractive errors, and excessive exposure to blue light, particularly during evening hours. Although these symptoms are usually temporary, their recurrent nature emphasizes the need for early recognition and preventive care. Effective prevention relies on simple and cost-effective strategies such as ergonomic screen positioning, regular visual breaks, conscious blinking, appropriate refractive correction, and limiting unnecessary screen time. Regular eye examinations and awareness of healthy screen habits play a crucial role in maintaining visual comfort. Public health guidance from Organizations such as the world health Organization underscores the importance of preventive eye care. By adopting healthy visual practices, individuals can continue to benefit from digital technology while protecting long-term ocular health.

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