Journal of Medical Clinical Case Reports

Computer Vision Syndrome - A Digital Eye Strain

Dr.Ragni Kumari[1], Jamshed Ali[2*], Salal Khan[2], Ramlah Akhtar[3] and Sunil kumar Gupta[2]

[1]Research Associate, Department of Optometry, Era University, Lucknow, India.

[2]Assistant Professor, Department of Optometry, Era University, Lucknow, India.

[3]Tutor, Department of Optometry, Era University, Lucknow, India.

***Corresponding author**

Jamshed Ali,
Assistant Professor,
Department of Optometry,
Era University, Lucknow,
India

Submitted : 1 Aug 2024 ; Published : 12 Sept 2024

Citation: Kumari, R., Ali, J., Akhtar, R., Gupta, S.K. (2024). Computer Vision Syndrome - A Digital Eye Strain. J Medical Case Repo, 6(3):1-6. DOI : https://doi.org/10.47485/2767-5416.1089

Abstract

Computer vision syndrome, often known as digital eye strain, is a collection of eye and vision issues brought on by using computers and other electronic devices. Today, a lot of individuals spend a lot of time in front of such devices. Up to 80% of users experience substantial symptoms both during and immediate after seeing electronic screen, because of the visual requirements are so different from those of conventional printed materials. The main ocular causes of this syndrome are reviewed in this paper, along with suggestions on how to adapt the routine eye exam to account for modern visual demands.

Keywords: computer vision syndrome (CVS), digital eye strain (DES), uncorrected astigmatism

Introduction

Electronic reading devices, cellphones, and desktop, laptop, and tablet computers are now widely used. Whether at home, at work, at downtime, or while traveling, staring at electronic screens has come to play a significant role in daily life in the modern era [1]. The U.S. Department of Commerce claimed in 2011 that 96% of working Americans utilize the Internet as a necessary component of their jobs, and it's probable that number has gone up since the time of the report's release. The day when printed papers are ultimately replaced by digital alternatives may be drawing near, despite the fact that the "paperless office" has long been anticipated but never materialized.

The amount of time people spend in front of displays on electronic devices is substantial. According to a 2013 research, American people watch digital media (including television, computers, and mobile devices) for an average of 9.7 hours every day. The fact that people utilize their cellphones on average 221 times every day, or 1500 times per week, is another proof of the ubiquity of technology. For a 16-hour workday, this equates to every 4.3 minutes.

It has been demonstrated that the children who spend more time on screens and engage in less physical activity have considerably smaller arterioles in their retinas [2]. It should be emphasized that viewing on digital electronic devices is not just for adults, teens, and older children. According to a research study, preschoolers can spend up to 2.4 hours per day in front of screens [3]. As a result, the American Academy of Paediatrics (2013) advised that children under the age of 2 years should not spend time in front of electronic screens [4].

It is of great concern to optometrists since the severity of ocular and visual symptoms associated with seeing these digital screens is much higher compared with printed materials given the significant number of hours spent in front of screens [5]. It is challenging to accurately estimate the prevalence of symptoms associated with electronic screens because both working conditions and methods of quantifying symptoms vary widely.

In a survey of New York City computer users, it was discovered that 40% of the participants reported having tired eyes "at least half the time," while 32% and 31% of the participants reported having dry eyes and eye pain, respectively, with same frequency. A study of computer users in New York City found that 40% of subjects reported tired eyes "at least half the time," while 32% and 31% reported dry eyes and eye discomfort, respectively, with the same frequency [6]. The prevalence of the symptoms differed considerably by gender (more prevalent in women), race (more prevalent in Hispanics), and rewetting drop usage. The Ocular Surface Disease Index, which measures dry eye, and computer-related visual complaints were shown to be significantly positively correlated. According to a recent American Optometric Association poll of 200 children between the ages of 10 and 17, 80% of respondents experienced burning, itching, eye fatigue, or blurred vision after using a digital electronic device.

These ocular and visual symptoms are known as computer vision syndrome (CVS) or digital eye strain (DES). The latter word is preferred since many people do not consider portable gadgets like smartphones and tablets to be computers. However, it is critical that the optometrist inquire each patient about their usage of technology.

Perspective

One important issue is the specific angle of view taken when viewing digital devices. A noted that desktop and laptop computers are most often viewed looking up and down, respectively (although this can vary for a desktop computer if multiple monitors are used) [7], while handheld devices such as tablet computers and smartphones can be positioned in almost any direction, sometimes even held to one side, requiring rotation of the head and/or neck. Because both the magnitude of heterophoria and the amplitude of accommodation can vary considerably depending on the viewing angle, it is important that tests be conducted under conditions as close as possible to usual working conditions [8].

Text Size

Furthermore, the size of the text being viewed may be quite small, especially for mobile devices, with a range of visual acuity needs for viewing a web page on a smartphone ranging from 6/5.9 to 6/28.5 (with a mean of 6/15.1) [9]. Reading text at or near the resolution threshold for an extended period of time might cause severe pain. It has been established that a twofold reserve is suitable for young, normally sighted persons while reading on a laptop [10,11]. This means that the font size should be at least twice the size of the person's visual acuity in order to allow for comfortable reading for an extended period of time. However, for older individuals or those with visual impairments, larger numbers may be necessary. For example, the smallest text size defined by would require a near visual acuity of 6/3. Few, if any, standard eye examinations record this level of near visual acuity [9].

Correction of Refractive Errors

Determining the proper refractive correction for the digital user also offers difficulties for the optometrist. Working distances can range from 70 cm for a desktop display to 17.5 cm for a smartphone [9]. These distances correspond to dioptric needs ranging from 1.4 D to 5.7 D. It is doubtful that a single pair of corrective lenses can offer clear vision over this dioptric range for the presbyopic patient.

Furthermore, minimal astigmatism correction may be essential. Two comparable studies investigated the impact of uncorrected astigmatism when reading text on a computer screen [12,13]. The authors noticed that uncorrected astigmatism of 0.50 D to 1.00 D resulted in a significant rise in symptoms in both studies. While astigmatism is often corrected in eyeglass users, it is not uncommon for mild to moderate astigmatism to go uncorrected in contact lens wearers. Because the physical presence of a contact lens on the cornea might aggravate symptoms associated with DES [14].

In addition to the discomfort of working at a computer, the symptoms of DES can have a major economic impact. Eye and vision problems can increase the number of errors made when working on a computer and require more frequent intervals. Musculoskeletal injuries associated to computer use may account for at least half of all reported work-related injuries in the United States [15,16] discovered that the yearly cost of musculoskeletal illnesses to the US economy in 2001, as evaluated by compensation expenditures, missed earnings, and diminished productivity, was conservatively estimated to be between $45 and $54 billion, or 0.8% of GDP. Furthermore, as many as 62% of computer employees suffer from neck, shoulder, and arm pain. Employers in the United States paid an estimated $20 billion in compensation payments due to work-related musculoskeletal ailments in 2002, in addition to productivity costs [17].

With regard to DES, it was anticipated that simply providing acceptable refractive correction could improve productivity by at least 2.5% [18]. This would result in an extremely favorable cost-benefit ratio for an employer computer-related eyeglasses to its employees. As a result, it is obvious that the economic effect of DES is highly massive, and decreasing symptoms that limit occupational productivity will result in considerable financial benefits [19].

Accommodation and Convergence

Given the substantial visual demands of near digital screens, all users of digital screens should undergo a full examination of accommodation and vergence. The parameters to be quantified are listed in Table 2. It is also crucial to utilize cross-not retinoscopy [8] and associated phoria (i.e., prism to minimize fixation disparity) to evaluate the actual accommodation and vergence response for the specific task demands. If an appropriate oculomotor response is not maintained, symptoms and/or loss of clear and simple binocular vision will occur.

Dry Eye

Dry eyes had previously been identified as a primary cause of DES [20], and dry eye symptoms were observed in 10.1% of male and 21.5% of female Japanese office employees who worked at VDTs. Furthermore, longer periods of computer use were linked to a higher incidence of dry eyes [21]. A thorough investigation discovered that computer users commonly experienced dry, burning, and irritated eyes after prolonged work, indicating that these ocular surface-related symptoms might be caused by one or more of the following reasons [14,22].

1. The environmental factors that contribute to corneal dehydration. These might include low humidity, high heating or air conditioning settings or fan use, excessive static electricity, or airborne pollutants.
2. Age and gender, the frequency of dry eyes increases with age and is higher in women than in males [23,24,25].

Blink Rate

Another reason for an increase in dry eye symptoms when viewing digital screens might be changes in blinking behavior. Several studies have found that blink rates decrease while working on a computer [26,27,28].

The blink rate of 104 office workers was compared while they were relaxing, reading a book, or gazing at text on an electronic screen [28]. The average blink rate was 22/minute while they were relaxed, but only 10/minute and 7/minute when they were gazing at the book and screen, respectively. Blink rates were shown to decrease when text size and contrast were reduced [29], or when the cognitive effort of the task increased. Computer vision syndrome (also known as digital) [29,30,31]. Thus, the variations identified by Tsubota and Nakamori may be due to changes in task complexity rather than the transition from printed material to an electronic screen.

A recent research in our laboratory compared blink rates when reading similar text from a desktop computer screen to those from printed materials [32]. Because there was no significant difference in mean blink rates, it was concluded that the previously reported variances were most likely related to changes in cognitive demands rather than presenting manner. While the use of a screen did not affect the overall number of blinks [32], there was a substantially larger percentage of incomplete blinks when individuals read on a computer (7.02%) compared to reading printed materials (4.33%). However, it is uncertain if changes in cognitive demands affect the percentage of incomplete blinkers. This is relevant since a significant correlation has been discovered between post-task symptom ratings and the percentage of blinkers classed as incomplete [32]. Interestingly, increasing the general blink rate (through an auditory stimulus) did not significantly lessen DES [33] symptoms. This might indicate that the existence of incomplete blinks, rather than a change in total blink rate, could be responsible for symptoms [34]. According to, inadequate blinking leads reduced tear layer thickness throughout the inferior cornea, resulting in considerable evaporation and tear dissolution. Our research group is now exploring the effect of blink efficiency workouts that reduce the rate of incomplete blinking on DES symptoms.

Accommodation and vergence tests that should be included in an evaluation of a viewers near vision system of digital displays. Accommodation tests refer to pre-presbyopic patients only

Test for Accommodation

Subjective accommodation amplitude (push-up or minus lens)
Accommodation behavior (cross-not retinoscopy) at the optimal working distance
Monocular and binocular accommodative ability (±2.00 lens)
Negative and positive relative accommodation Relative accommodation
Vergence testing

Near point of Convergence

Distance and near heterophoria (near at desired and/or needed working distance)
Horizontal fixation disparity/associated phoria at optimal working distance
Vergence (using 12-base-out/3-base-in prisms or a Hart table)
Base-in and base-out vergence ranges
presence of A and V patterns
Stereopsis

Asthenopia

According to a study of asthenopia, common symptoms include ocular strain, ocular tiredness, discomfort, burning, irritation, pain, soreness, diplopia, photophobia, blurriness, itching, tearing dryness, and foreign body sensation [35]. These authors discovered two major kinds of symptoms while studying the effects of diverse symptom-provoking circumstances on asthenopia. The first group, known as external signs, comprised dry eye symptoms such as burning, irritation, eye dryness, and weeping. Internal symptoms include eye strain, headache, eye discomfort, diplopia, and blur, and are typically caused by refractive, accommodative, or vergence problems. As a result, the authors suggested that the location and/or description of the symptoms may be used to identify the underlying issue.

It has been proposed that the change in blink rate is due to the poorer image quality of the electronic screen compared to printed material [5]. However, for a given cognitive load, the image quality reduction induced by 1.00 D uncorrected astigmatism or displaying the target with a contrast of just 7% did not generate a significant change in blink rate [36]. Furthermore, induced refractive error, glare, diminished contrast, and accommodative stress (variation of the accommodative stimulus by 1.50 D throughout the duration of the task) increased blink rate [29]. Furthermore, it was shown that using an anti-reflective sheet to reduce glare on a computer display resulted in a significant reduction in blink rate [37].

The blue light Hypothesis

Although there is no published data to support this hypothesis, it has recently been proposed that the blue light emitted by digital screens may be a cause of DES. Fortunately, the human retina is protected from harmful short-wavelength radiation by the cornea, which absorbs wavelengths below 295 nm, and the crystalline lens, which absorbs wavelengths below 400 nm [38]. However, because shorter wavelengths have more energy, shorter exposure durations can still cause photochemical damage. These factors have been connected to the onset of age-related macular degeneration [39].

Considering that many different blue filter glasses are now available for the treatment of DES (e.g., Hoya Blue Control, SeeCoatTM Blue (Nikon), and Crizal Prevencia (Essilor), additional research is required to identify the effectiveness and mechanism of action of these filters.

Figure 1

Figure 2

They have the advantage of reducing eye movements away from the direction of travel [40]. However, if the projected picture is in a different direction or at a different perceived distance from the real fixation point, it might result in numerous, different stimuli. Other types of wearable technology may provide further challenges. Wrist-worn displays, for example, the Apple Watch (Apple, Cupertino, CA, USA: Figure 3) may display extremely small text due to the limited screen area (approximately 3.3 cm x 4.2 cm), but wrist-worn technology can be of great benefit to disabled individuals who require a hands-free device, such as for facial recognition in visually impaired individuals and monitoring eye and head movements in Parkinson's disease patients [41].

Figure 3

In many ways, the visual conflicts described by Google Glass are similar to those described by users of spectacle-mounted biotic telescopes, in which the telescope is mounted high on the wearer's lens so that the patient can move around while wearing the device, but can still use the telescope to 'sight in' on a more detailed distant target when needed.

Discussion

As a result, the prevalence of reported eye strain is expected to rise further as the population gets older, along with the associated age-related increase in hyperopia, astigmatism, dry eyes, and loss of media transparency, not to mention that all of these people will be presbyopic. Given the remarkably high number of hours per day that many (or perhaps most) people spend viewing small text on electronic screens at low working distances and changing viewing angles, all ophthalmologists must have a good understanding of the symptoms associated with DES and the underlying physiology, DES. As modern society rapidly relies on electronic gadgets for both work and play, the visual demands imposed on these devices are certain to increase. Patients will experience significant lifestyle challenges and frustration if they are unable to satisfy these visual expectations.

Between 1985 and 2010, the average age of the population in the United Kingdom became from 35.4 to 39.7 years. The average age will likely increase to more than 42 years by 2035. Furthermore, by 2035, approximately 23 percent of the overall population of the United Kingdom is predicted to be 65 or older.

The usage of eyeglass-mounted video cameras among the sighted may become commonplace. A limited number of police departments, for example, are already using them to record officers' actions. As technology advances and shrinks, it's easy to picture a video camera hidden in an eyeglass frame or lens, with its image wirelessly transferred to a recorder (maybe a smartphone in a pocket) or to remote location where it could be seen in real time by a third party [42]. Interestingly, several people reported headaches and other visual issues when they initially used the gadget. Furthermore, the device caused considerable loss of vision in the upper right visual field [43].
Furthermore, blue light has been strongly implicated in the control of circadian rhythms and sleep cycles, and irregular light conditions can contribute to sleep deprivation, which may affect mood and task performance [44]. Indeed, it has been shown that young people use of electronic devices, especially at night, increases the risk of shorter sleep duration, more delay to sleep onset, and sleep deprivation [44].

However, according to a recent study, [45] wearing blue filters while working on a computer may be beneficial. The researchers investigated the effect of low, medium, and high-density blue filters (in the form of round spectacles) worn during computer work in groups of patients with dry eyes and normal eyes (n = 20 for each group).

Conclusion

It is possible that the current technology revolution will be compared to the 19th century industrial revolution in the future. However, today's visually appealing needs change significantly from those of the past. The viewing distance, required viewing angle, symptom intensity, and blink patterns of digital electronic gadgets differ greatly from those of printed materials. As a result, eye exams must be modified according to these new standards. Another factor to consider is the growing elderly population in Western Europe and North America.

Conflict of Interest

The author has no financial connection to any of the products mentioned in this article.

Source of Funding

None

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