Review Article

Computer Vision Syndrome: Is it being Diagnosed and Managed Properly?

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Abstract

Computer and mobile computing devices such as laptops, tablets, or cell phones are being used by increasingly large number of people today. This has led to variety of ocular symptoms which includes eye strain, tired eyes, irritation, redness, blurred vision, and diplopia, collectively referred to as Computer Vision Syndrome (CVS). CVS may have a significant impact not only on visual comfort but also occupational productivity since between 64% and 90% of computers users experience visual symptoms which may include eye strain, headaches, ocular discomfort, dry eye, diplopia and blurred vision either at near or when looking into the distance after prolonged computer use. So, CVS acts like slow poison for ocular and visual comfort, if not taken into consideration timely. CVS has a multifactorial causation. Several factors have been linked to symptoms. But how often has it been diagnosed and managed properly? The answer is "not satisfactory". Most of CVS cases have been dispensed merely with eye drops and no other orthoptic interventions and ergonomic awareness are suggested, especially in developing countries like Nepal. A specially designed ocular examination for computer users and associated counseling about the current good practice in computer use would go a long way in preventing loss of productivity and morbidity from the condition.

Keywords: Binocular Single Vision Disorder; Blue Light; Computer Vision Syndrome; Dry Eyes; Ergonomics

Introduction

Computer use is becoming very prevalent in the modern digital world with its usage almost unavoidable in every aspect of human life. Computers have created a very effective information system to help streamline the management of an organization rendering it a much-needed tool for every business, banking, government, entertainment, medicine- health, daily life, industry, education, and administration. The social changes have led to computers and mobile computing devices being everywhere. However, the numbers of patients complaining about ocular and non-ocular symptoms have increased tremendously. The ever- increasing reliance on the computer is tolling upon a pitfall to a variety of symptoms which have been termed computer vision syndrome (CVS).

CVS, also called Digital Eye Strain (DES) is defined as a complex of eye and visual problems related to the activities which stress the near vision and which are expected in relation, or during the uses of computer [1]. The American Optometric Association (AOA) has defined CVS as a group of eye and vision-related problems that result from prolonged computer, tablet, e-reader and cell phone use [2]. Many individuals experience eye discomfort and vision problems when viewing digital screens like computers, tablets, e-readers and cell phones for prolonged period of time. The visual demand has increased compared to past decades with development and dependence on portable-handy mobile phones. These devices have relatively small screens and small text sizes that may necessitate close working distances. CVS is caused by the eyes reacting differently to characters (pixel) on the screen than they do to printed characters. Healthy eyes can easily maintain focus on the printed page [3,4]. Characters on a computer screen, however, don't have this contrast or well-defined edges. Each pixel is bright at its center and with decreasing brightness towards the outer edges. Therefore, electronic characters have blurred edges as compared to letters on a printed page with sharply defined edges [3]. This makes the human

eye very difficult to maintain focus on pixel characters. And in an attempt to focus on the plane of the computer the eye fails to sustain the focus, therefore relaxes on to focus behind the screen. This point is referred to as the Resting Point of Accommodation (RPA) or sometimes called the dark focus [3]. This increase the demands placed upon ocular accommodation and vergence [5]. Therefore, the eye is constantly relaxing to RPA and straining to refocus on the screen which leads to eye strain and fatigue [3].

Furthermore, with the emergence of computer use in the education sector has inclined the tendency of CVS not only among adult computer workers, but also in school, college and university students. This has emerged CVS as a public health issue, rather than condemning it as a visual discomfort. Therefore, the burden of CVS should draw the attention of policy makers and researchers as soon as possible.

Although, the term computer vision syndrome (CVS) is accustomed, authors including Mitchell Scheinman bring into the question the use of term "Syndrome" for symptoms that stems solely due to computer use, rather than due to any specific disease related to vision. Therefore, the term "computer vision syndrome" has been called into and is outplaced by the term "computer use complex" [6], owing to the medical meaning of "complex" which basically means a group of diseases or symptoms associated with similar etiologies [7]. Thus, symptoms associated with computer use are more similar in this respect to a complex rather than syndrome [6]. Hence, any symptoms, physical or visual, that is related to computer use is termed "Computer Use Complex" which is often referred to as "Computer Vision Syndrome".

Prevalence

Owing to the technological advancement and growing socioeconomic development observed in the world, the use of computers has been increased dramatically, and so does its prevalence. Gauging prevalence is challenging due to the wide variety of usage conditions (both vocationally and socially) and substantial changes in these over times, along with the range of methodologies that have been applied to identify sufferers [8]. Research has found that around 75% of the population working in front of a digital screen for 6 - 9 hours daily complains of some ocular discomfort [9]. Office based studies have shown the prevalence of CVS to the higher in women than men [10], but similar between the contact lens and spectacle wearers [5]. The finding of greater computer-related symptoms in females was in agreement with 2012 findings among a cohort of 520 office workers in New York City [11] and may be linked to gender differences in dry eye prevalence [12,13]. However, on a study conducted among Spanish civil servants, with six or

more hours of computer use, contact lens wearers were more likely to be affected than non-wearers, with the prevalence of 65% and 50%, respectively [14]; whose finding was attributed to possible incomplete removal of superficial deposits with multipurpose lens care solutions and/or the mechanical interaction of silicone hydrogel lenses with the ocular surface [14]. Although little attention has been given to the prevalence of CVS among pediatric population in the literature to date, a pooled prevalence of 19.7% [15] should be meta-analyzed. The positioning of the computer and eye-level of the user is also known to affect the prevalence of CVS. On a research conducted at IOM, Tribhuvan University among MBBS students, about 69.5% of students used a computer at the level of the eye but there was a significant reduction in Computer vision syndrome (p-0.0001) among those who had computer screen below the eye level [16]. Duration of computer use with symptomatic encounter also seem to play a role. A study conducted among medical students and engineering student whose day hour of computer use was more than 4 - 6 hours and less than 4 hours per day respectively concluded that, among engineering students, the prevalence of CVS was found to be 81.9% while among medical students; it was found to be 78.6% [17].

Etiology, causes and risk factors

Various etiological factors have been known to be associated with the cause and risks of CVS. The causes of CVS are a combination of individual visual problems and poor visual ergonomics. So, we have simply grouped under two broad sub-headings:

1. Ocular factors
2. Non-ocular factors

Ocular factors

- **Uncorrected refractive error**: Preexisting uncorrected refractive problems can increase the severity of CVS [18]. Individuals who are prescribed spectacles have to tilt their head at odd angles because their spectacles aren't designed for seen at the computers which may not be ergonomically correct. Such posture can result in muscle spasm or path in the neck, shoulder or back.

- **Reduced eye movements**: When eyes concentrating on a computer screen, the range of motion of eye decrease than the activities in which eyes are not focused. This reduction of eye movements dehydrates the eye, which can lead CVS.

- **Reduced eye blinking**: Blinking rate reduces with prolonged use of computer from 20 - 22 times per minute during the normal hour to only about 4 - 6 times per minute during computer use. The reduction in blink rate, increased surface of cornea

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exposure caused by horizontal gaze at the computer screen resulting in corneal dryness and redness of the eye. Since blinking is important for hydration of eyes, reduced blinking is also considered as the cause of dry eye and CVS.

- **Dry eye disease and tear film dysfunction:** Evaporative dry eye is caused when the blink rate is decreased. Prolonged viewing is another important factor which is not only unnatural for the human optical system causing strain but also contributes to dry eye. Dry eye causes people to arch their foreheads in an effort to see better and cause headache [19,20]. Evaporative dry eye is also caused by air- conditioners in the workplace and home.

- **Oculomotor imbalances, accommodation and BSV dysfunction:** Significant oculomotor imbalances cause unnecessary eye strain. Accommodation dysfunction causes visual discomfort especially in near and intermediate viewing conditions. Accommodative anomalies including poor facility and high lag may reduce visual comfort during near work, including computer use [8].

- **Presbyopia:** Presbyopia is the normal age-related loss of a person's ability to focus sharply for near vision (i.e., inability to focus sharply on close objects). Research indicates presbyopic workers over 40 years old are at increased risk for symptoms associated with CVS.

Non-ocular factors

- **Low contrast and brightness**: Studies have shown that the computer monitor is populated by pixels, the focus on the computer screen is different for eyes and these tiny dots are not uniformly bright and produce little difference in contrast as a result of which even at high resolutions, the edge of the letter looks blurry which adds to strain on eyes and is one of the important causes of CVS [21].

- **Duration of computer use**: Prolonged viewing of a computer screen for more than 2 hours, especially at a constant depth of field, is the primary cause of CVS [16]. In study it was reported that a transient myopia was observed in 20% of computer users at the end of their work [9].

- **Position of monitor:** Monitors that are either too far away or poorly angled in relation to the location of the user's eyes can cause the user to assume awkward postures.

Besides, the user related factors have also been known to cause CVS. Monthly salary, occupational status, daily computer usage, history of previous eye problems, and knowledge on safety measures

of CVS and its adverse effect were found to be determinant factors for CVS [22].

Symptoms

The symptoms of CVS may vary depending on various factors which includes periods of time spend, viewing distance, seating position, computer screen level, and visual acuity disturbances. The problems that lead to CVS are not necessarily unique to computers, but are the same problems patients encounter in other near-point tasks [23]. Symptoms associated with computer vision syndrome (CVS) are [2]: Eye strain, Headache, Blurred vision, Dry eyes, Neck and shoulder pain, Double vision, Red eyes, Eye Irritation, and Photophobia. Apart from CVS, their usage, even for three hours per day, leads to a health risk of developing Occupational Overuse Syndrome (OOS), low back pain, tension headaches and psychosocial stress [23]. Sheedy categorizes the various symptoms into one of the following groups [24]:

- **Visual symptoms**
    - Blurred vision or squinting (constant, intermittent, when changing viewing distance)
    - Frequently losing place
    - Diplopia.

- **Non- visual ocular symptoms**:
    - Irritated eyes (itching, burning, dry, aching or red eyes)
    - Excessive tearing
    - Excessive blinking
    - Contact lens intolerance.

- **General asthenopia:**
    - Eyestrain
    - Headaches
    - Fatigue.

- **Sensitivity to lights**:
    - Glare, or annoying brightness
    - Flickering sensation (less common, especially with modern computer displays.

- **Musculo-skeletal symptoms**:
    - Neck, shoulder or back pain
        - Shoulder, arm or wrist pain.

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Signs of CVS [6]

- **Exophoria**
    - Receded near point of convergence
    - Basic exophoria
    - Greater exophoria at near than at distance
    - Low AC/A ratio
    - Reduced smooth/step vergence
    - Reduced fusional facility
    - Low negative relative accommodation
    - Low monocular estimation method retinoscopy finding
    - Difficulty with plus lenses during binocular accommodative facility (BAF) testing.

- **Esophoria**
    - Receded near point of convergence
    - Basic esophoria
    - Greater esophoria at near than at distance
    - High AC/A ratio.

- **If accommodative excess is also present:**
    - Difficulty with plus lenses during monocular accommodative facility (MAF) testing.

- **If accommodative insufficiency is also present:**
    - Difficulty with minus lenses during MAF and BAF testing
    - Low positive relative accommodation
    - Low amplitude of accommodation.

Implication of CVS

Although, most of the symptoms associated with CVS are temporary and ceases with decreased use of computers, the implications of untreated CVS especially among heavy computer users must not be ignored. If problems leading to consistent eye strain are not resolved, repeated experience of these issues can lead to reduced visual acuity after stopping work on the screen, and this may get worse [25]. Persistent accommodation efforts may result in transient myopia or accommodation spasm, which further contributes to symptomatic encounter with accommodation dysfunction along with that of CVS. Evaporative dry eye which results from reduced eye blinking for a long period of time may further cause ocular discomfort, irritation and inflammation. Frequent eye rubbing may cause recurrent blepharitis, Stye and other eyelid abnormalities. Moreover, extensive eye rubbing may also result in a change in the refractive status of the eye by altering the shape of the cornea; worse scenario is, it may result in keratoconus.

Blue light emitted by the artificial light source disrupts the normal circadian rhythm. Circadian cycle is responsible for many physiological processes including the sleep-awake cycle, body temperature and food intake. Exposure to artificial light in the evening, when our circadian timing system is most vulnerable to light, has the capacity to modify rhythms and thus sleep and neurobehavioral function [26]. Thus, poor sleep and insomnia may result due to CVS.

In addition to the discomfort experienced during computer operation, symptoms of CVS may also have a significant economic impact [5]. The symptomatic encounter may decrease the work productivity. Musculoskeletal injuries associated with computer use may account for at least half of all reported work-related injuries in the USA [27]. Accordingly, it is clear that the economic impact of CVS is extremely high and minimizing symptoms that reduce occupational efficiency will result in substantial financial benefit [5].

Diagnostic procedure: Computer vision syndrome can be diagnosed through a comprehensive eye examination.

- **Patient history and symptoms:** Patient history is being taken to find out the underlying cause and presence of any general health problem, under medication, or environmental factors that may be contributing to the symptoms related to the computer use along with the documentation of symptoms (visual and physical) and ergonomic issues [23].

- **Measurement of visual acuity:** Both near and distance vision is assessed to detect how much vision is affected.

- **Refraction:** Very fine refraction is done to detect the appropriate lens power needed to overcome of any refractive error (myopia, hyperopia and astigmatism). In some cases cycloplegic refraction is done to find out exact power [18].

- **Eye health evaluation**: Anterior and posterior eye health evaluation is assessed to detect any abnormalities present.

- **Dry eye evaluation:** Computer use has been associated with both a reduced rate of blinking and a high number of incomplete blinks when compared with viewing hard copy materials [3]. Studies have shown that longer periods of computer work were also associated with a higher prevalence of dry eye [28]. A diagnostic test for dry eye includes:

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- Tear break-up time (TBUT) test: To evaluate tear-film stability

- Ocular surface dye staining (Fluorescein/rose Bengal/lissamine green) test: To evaluate ocular surface disease

- Schirmer test: To evaluate aqueous tear production.

- **Comprehensive strabismic binocular vision evaluation:** CVS is basically an outcome of a binocular dysfunction, a decompensation of accommodative-convergence synchronization. The Patient encountered with CVS presents with binocular vision anomalies. The detailed binocular vision evaluation is a must in every patient which includes:

  - Stereopsis measurement

  - Worth-4 dot test

  - Ocular motility (version) test

  - Cover/uncover and alternate cover test

  - AC/A ratio

  - Near point of convergence

  - Near point of accommodation

  - Monocular estimation method retinoscopy

  - Negative and positive relative accommodation

  - Fusional vergences [Base-in and Base-out]

  - Accommodative facility

  - Vergence facility

  - Evaluation of eye movement.

Management: The management scheme of CVS is no different than treating any binocular vision disorders. Special consideration in the management of CVS is tabulated below [6].

Sequential consideration in management of CVS
•   Optical correction of ametropia
•   Added lens power
•   Prism (horizontal/vertical)
•   Occlusion for amblyopia
•   Vision therapy for amblyopia
•   Vision therapy for suppression
•   Vision therapy for sensory motor function
•   Surgery
•   Ocular health management
•   Ergonomic issues

Table

Correction of ametropia

Best correction of underlying ametropia by appropriate spectacle correction may solve visual symptoms of CVS which includes muscular asthenopia and accommodative fatigue. Small astigmatic correction, particularly, against the rule or oblique seems to be significant for many patients, as do small hyperopic corrections [6]. Eye glasses help to increase the clarity of the computer screen for both young and old patients and improve their overall comfort. For patients 40 hours per week, reading glass help to reduce the strain on their eyes. Even patients greater than 40 years of age can also get benefit from a modified reading glass, called as digital glasses [29]. Therefore, the correction of refractive error forms the first step in the management approach.

Added lens

Added plus lens will benefit those patients with CVS who has high AC/A ratio and exhibit esophoria at near. Apart from visually correcting the symptoms of presbyopia and accommodation dysfunction (ill- sustained accommodation, accommodation insufficiency), added plus lens relieves visual symptoms of CVS. Flat-top bifocal design may be problematic for patients with CVS, as it requires the patient to raise their chin to use the bifocal zones. So, executive bifocals are preferred.

Prisms

Prisms are particularly useful in those patients who have significant binocular vision dysfunction apart from CVS, especially in those with esophoria or vertical phorias for which horizontal and vertical relieving prisms are prescribed respectively.

Ergonomics

Modifying or improving the work environment is also important in relieving symptoms of CVS. Ergonomic issues to be considered include:

- **Proper chair designing:** A Well-padded comfortable computer chair is required, which also provides rest to feet. The chair should be adjustable so as to place foots on the ground and have a typical arm supporting while typing.

- **Consider proper reading source placement:** During computer use, reading materials should be ideally place below the monitor and a document holder, the aim is to position reading material in such a way so as not to move head between document reading and computer screen reading [4].

- **Consider proper room lighting:** It is important to position monitor to avoid direct glare from lighting sources by use of low voltage bulbs and fluorescent tubes [2]. Exterior light

should be eliminated by closing drapes, shades or blinds and interior lighting should be reduced by using fewer light bulbs.

- **Ideal computer screen positions:** Ideally the computer screen which are 15 to 20 degree below the eye level and which are kept at a distance of 20-23 inches from the eyes gives great comfort [4].

Ocular health

Eye health especially tear film integrity and eyelid hygiene are important aspects that should be considered while treating visual symptoms of CVS. This includes:

- **Exercising the eyes:** To get rid of tiring eyes by constantly focusing on the computer screen, "20-20-20 rule" must be followed [29]. It means-look away from the computer screen at least every 20 minutes and gaze at least 20 feet away for at least 20 seconds [30].

- **Rest and blinking:** To decrease the risk of dryness while working on computer screen, the exercise of 30-30 can be tried. After 30 minutes of computer work, eyes should be closed for 30 seconds [28]. Blinking is very important when working on computer screen as it moistens eyes to prevent dryness and irritation. Wide gaze angle results into a greater percentage of incomplete blinks due to constantly focus on a single source; risk of development of CVS [31].

- **Taking frequent breaks:** To reduce the risk of CVS and neck, back and shoulder pain, frequent breaks and gentle exercise for neck is recommended every two hours [30].

- **Eye medications:** Artificial tear drops lubricate the eyes and provide comfort to the eyes.

- **Minimize glare:** By installing an anti-glare screen on monitor and if possible, painting bright white walls with a darker color with matte finish. Another way to minimize glare is by using anti-reflective coating (ARC) glasses. Replacing an old tube-style monitor with a flat-panel liquid crystal display (LCD) which has anti-reflective surface is another beneficial change. For ideal desktop, it is recommended to select a display that has a diagonal screen size of at least 19 inches [30].

Vision therapy

Computer vision syndrome is an outcome of a binocular dysfunction, a decompensation of accommodative-convergence synchronization which results into near point asthenopia. Vision therapy is an important step in the management of accommodative and vergence problems. Vision therapy is a complete program of habilitative and rehabilitative therapeutic vision care used to develop, restore, or enhance visual function and performance. In-office VT

once or twice weekly for 30 minutes to an hour with supplemented procedures done at home between office visits will help patient encountered with CVS [6,32].

Surgery

Surgeries typically do not have much role in CVS, unless a significant heterophoria is seen.

Conclusion

CVS is a very common problem that has been emerging in this century due to prolonged uses of computer screen, tablets, cell phone and other digital screen both at home and at office. There is relationship between ocular symptoms such as pain, redness, dryness, head and neck sprains, blurring of vision and double vision with computer usage. Most of the research observed that prevention remains the main strategy in managing of computer vision syndrome. The modification in the working station, patient education and proper eye care are important strategies in preventing Computer Vision Syndrome. Every professionals and non-professionals VDU users should timely take it seriously and stay less affected by this slow poison of CVS.

Financial Interest

None

Conflict of Interest

The authors declare that they have no competing interest. All authors have agreed to authorship and order of authorship for this manuscript.

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