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Review Article

Various Ocular Problems Associated with the Use of the Digital Screen: A Narrative Review

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Abstract

The study's objectives were to evaluate the various ocular symptoms on a digital screen, develop healthcare recommendations to lessen user eye discomfort, and contribute to the development of digital devices that are less likely to cause visual and ocular pain in general users. A review of reports released between 2001 and 2022 was finished, and a literature search utilizing PubMed, Google Scholar, and original articles released up until January was conducted. The terms "Digital display screen", "Blue blocking filters", "Digital eye strain", and "Video display terminal" were utilized as keywords. We searched for papers on the impact of binocular vision using the terms "accommodation", "convergence", "vergence", and "phoria." To identify the impact on the ocular surface, the phrases "tear film", "blink rate", "blink amplitude", "blinking", "dry eye", "tear function", "tear amount", and "tear break-up time" were employed, the research on digital screen use conclusively reveals a rise in ocular and visual symptoms like headaches, eyestrain, dry eyes, irritated eyes and one of the reasons being is incomplete blinking. It is unknown if using several devices has a higher impact on the visual system and ocular surface, and it is also unclear how switching between screens would affect accommodation and vergence.

Keywords: Video Display Terminal (VDT); Accommodation; Fusional Vergence; Computer Vision Syndrome (CVS)

Introduction

The use of digital screens has increased, irrespective of the shape and size of the screen, in recent years. We should think about how these smart devices affect us physically as they become increasingly important and incorporated into our daily life. Today's patients of all ages often use electronic devices to read small print for extended periods, often at close ranges [1]. Eye strain, blurriness, dryness and irritated eyes are among the visual and eye symptoms linked to prolonged usage of intelligent devices. Furthermore, increasing near working hours with digital screens can increase the demand for accommodation and vergence, resulting in ocular fatigue [2]. The use of computers/smartphones in various fields of work has expanded significantly. With the incidence of the COVID-19 pandemic and the recommendation of social distancing and quarantine throughout the world, digital screens and smartphones have increased drastically. The use of digital video units has become a massive part of daily life for working, studying, and leisure activities with an increasing preference for smaller-screen devices, such as tablets, laptops, and smartphones, and shows that the main abnormal changes in accommodative and binocular vision status in VDT users [3]. Among these technologies, smartphones are one of the most affecting in the last decades.

According to many studies, emerging adults' eye fatigue and blurred vision can increase by as much as 5 times after an hour of using a tablet or smartphone. The accommodative/vergence system, the ocular surface (including blinking), or a blend of the two may be to blame for these groupings of symptoms. The kinds of symptoms that have been observed with portable devices are comparable to those that have been described with PCs, where the study has so far concentrated. The adverse consequences of computer use, known as CVS, are like those previously stated. The accommodating mechanism and eye surface may be affected in the short- and long-term by such a syndrome, which has been described by 20–40% of computer users [4].

Also, blink counts when rested were 22 per minute, but when looking at a book or display, they were just 10 and 7 per minute, respectively. Also impacted by CVS are young teens, who exhibit less vergence and accommodation as a result [5]. Eyestrain and ocular surface symptoms increased after 60 minutes of use of smartphones. There was no significant change in the tear film and blinking rate, but it was associated with worsening the overall ocular surface symptoms score and binocular function [6]. All the symptoms were significantly worse during the COVID-19 breakthrough, which denotes that digital device users need to educate by eye care practitioners on preventive measures [7]. Marketing is done with different blue-blocking filters to reduce the symptoms of eye strain. However, it has failed to live up to the mark and showed was no more effective at reducing symptoms and did not change the orbicularis oculi muscle activity [8,9]. And also following an hour of continuous e-reader use, eye symptoms of eyestrain and discomfort were considerably different from those experienced after reading a paper copy under identical viewing circumstances. In contrast to the print "control" group, the iPad study group experienced eyestrain and discomfort more frequently [10].

Methodology

A literature search was carried out using PubMed, Google Scholar, and original articles published till January. The following relevant keywords terms were used "Digital display screen", "Blue blocking filters", "Digital eye strain", and "Visual display terminal. "The phrases "accommodation", "convergence", "vergence", and "phoria" were used to find articles on the effects of binocular vision. The terms "tear film", "blink rate", "blink amplitude", "blinking", "dry eye", "tear function", "tear quantity", and "tear break-up time" were used to search for the influence on the ocular surface. All the relevant articles were thoroughly assessed, and the references sections of the identified research paper were examined to find additional relevant articles to help ensure the completeness of the search. The inclusion criteria were original articles published only in English between the year 2001 to 2022, the purpose of which was to investigate the various ocular problems associated with using a digital screen and its associated factors. Studies from around the world were included. First, the studies' suitability was evaluated based on their titles and abstracts. All selected studies have finished full papers, and the decision to include the study was made only after carefully reading the paper. The exclusion criteria were studies that were not focused on smartphone or computer use. In the next step, the full texts of articles were checked according to the eligibility criteria, and 25 articles fulfilled the criteria for being included in the principal analysis.

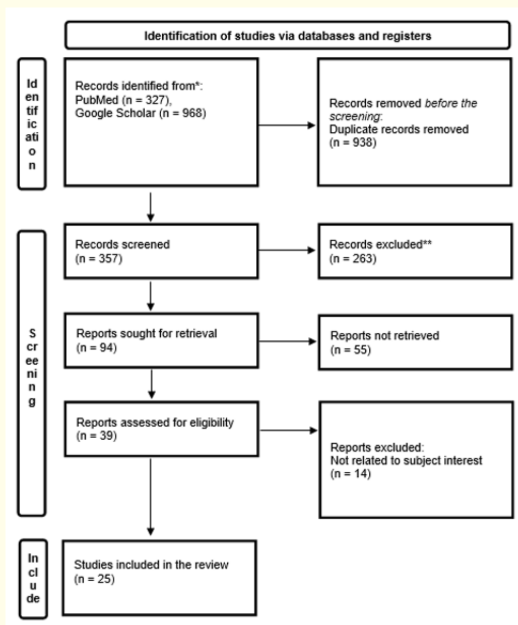

Figure 1: Flow diagram showing the selection process for the eligible studies [11].

Result and Discussion

Blinking and blink rate

The tear film is equally distributed throughout the ocular surface by the mobility of the lids during a blink. In a study by Doughty., *et al*. The various blink assessment methods used in different studies make comparisons difficult. Techniques include seeing the upper eyelid move downward, capturing the lid motion on video, and identifying blinks using electrophysiological impulses. Reduced blink rate is consistently divulged with computer use [12]. In A study by Hirota., *et al*. office employees who used computers found that their blink rates were lower than those of non-users, and they began to blink less quickly after using the computer than they did just before [13]. According to a study by Portello., *et al*. participants with the lowest blink rates and the most significant percentage of incomplete blinks exhibit the worst CVS symptoms. These rather prevalent diseases need to be alleviated; hence therapies must be created to enhance the anterior ocular surface [14]. A Study by Christina A Chu demonstrates a notably higher rate of incomplete blinking by using a computer than when carrying out the same work with hard copies in the same circumstances. When blinking less frequently, the inter-blink period increases, allowing more tears to evaporate and irritating the ocular surface. This shows that higher eye pain may occur due to a lower blink rate caused by increased attention on a computer job [15].

Tear film and dry eye

In a study by Nikol L Himebaugh., *et al*. the increased degree of ocular discomfort experienced at night, especially in dry eye sufferers, may be explained by decreased and incomplete blinking and elevated tear film break-up during typical visual tasks. Ribelles., *et al*. found that differences in the tear film content, such as reduced mucin synthesis, elevated inflammatory markers, and higher tear osmolarity, which were observed in computer users, have not yet been evaluated in phone and tablet users. Office workers who utilized computers had higher levels of pro-inflammatory mediators in their tears compared to those who did not. In a study by Miki Uchino., *et al*. Schirmer test findings also showed that most VDT users had a normal lacrimal function. These findings diverge from those made public by Nakamura and colleagues, who hypothesized that an aqueous deficit would occur from years of continuous VDT use. The discrepancies between these data may be explained by the fact that the cumulative impact of prolonged VDT labor was not measured in the current investigation. It has been showed that higher tear evaporation brought on by extended blinking intervals when looking is a factor in the development of dry eyes associated with VDT [16]. According to Dong Ju Kim., *et al*. the TBUT and the questionnaire had a discernible difference before and after the work. This raised the possibility of asthenopia brought on by dry eyes carried on by using smart devices. Prolonged use of digital screens reduces the blink rate, and blinks are also a partial type, so evaporation from the ocular surface happens to cause dry eye [17].

Corneal staining

Publications need to describe how using a smartphone or tablet affects the integrity of the cornea or conjunctiva as determined by vital dye staining. There are inconsistent claims regarding computer use and staining. Seven hours after using the computer, Yazici., *et al*. indicate that lissamine green remains visible on the cornea and conjunctiva [18].

Accommodation

The symptoms associated with utilizing digital gadgets may be linked to differences in the accommodative system, including alterations to the system's amplitude, accuracy, and facility. According to Rezvaneh Zamani Shahri., *et al*. both eyes' accommodation lag was statistically significantly affected after using a smartphone up close for an hour. Visible tiredness results from lag in accommodation, which can also affect other aspects of binocular vision. Taking frequent breaks when using a smartphone is advised. Comparing various near activities in a larger spectrum of refractive error requires more research. A lag in accommodation is defined as the difference between the accommodative response and the dioptric stimulus to accommodation. Near blur, painful, and weary eyes may develop when this difference is more significant than the depth of focus [19]. Study of mobile phone users under the age of 35 by Mijung Park., *et al*. has found that using a smartphone causes a delay in adjustment that is longer than the lag caused by reading printed material [20]. In a study by Jennifer E Hue., *et al*. reading speed (measured in words per minute) was noticeably slower when reading from the iPod. This was most likely brought on by the comparatively small screen, which showed fewer words per line and necessitated more scrolling. However, the mean accommodative response was also considerably lower when reading from the iPod as opposed to printed materials [21]. Joeng

Woo Wang., *et al*. The accommodation change was more pronounced after using a smartphone with a small display as opposed to when using a tablet with a bigger screen. Additionally, intelligent gadgets with reduced display sizes may cause more ocular irritation. The findings of this study propose that the display size of digital devices should be modified under the user's accommodative functions and ocular discomfort when using intelligent devices since it can have diverse impacts on the eye. Also, it has been found that chewing gum prevents reductions in perceived accommodation and enhances the eye's capacity to focus on healthy people, especially in young adults who experience eyestrain. This is due to the parasympathetic nerves' effect [22].

Fusional vergence

The convergence and accommodative systems collaborate while doing near tasks, making up two of the triad's three components. The most prevalent vergence condition with symptoms that appear with near employment is convergence deficit, which is characterized by exophoria at near. Clinical measurements of vergence are positive and negative fusional vergence, which are determined by increasing base out and base in prism till fusion breaks. In a study by Concepción De-Hita-Cantalejo., *et al*. findings show that more preteens with severe CVS than those with mild CVS acquired vergence problems and poor convergence skills resulted in the symptoms reported while using devices. Because of the pandemic, students at private schools are more likely to use digital devices [5]. Using a smartphone to read the text for 30 minutes showed a notable effect on the accommodative and vergence components for near activities, with the vergence system being more impacted. Exposure to these devices may cause binocular vision impairment and ocular tiredness considerably early in young adults. Therefore, taking regular breaks while reading on cell phones may be advised [23]. Hyo Seok Lee found out that after giving up smartphones for a month, the eso deviation drastically decreased in children between the ages of seven and sixteen who had acute acquired comitant esotropia and used them at least four hours every day. It is crucial to remember that this study only included kids with a specific type of esotropia, and no proof that using a smartphone contributed to it [24]. University students were randomly chosen, and binocular dysfunctions were more prevalent than accommodative and binocular dysfunctions [25].

More study is needed to consider the variety of ways that smartphones and tablets are used. Smartphones, which have portable screens of various sizes, are utilized at working distances that vary significantly from person to person. Screens can change their brightness manually or automatically, in contrary to computers, which are frequently fixed and rarely modified by the user. The use of computers for extended periods to simulate office environments has been studied in research; however, smartphones can be used often, sporadically, and throughout the day during all waking hours.

Summary

The research on digital screen use conclusively reveals a rise in ocular and visual symptoms like headaches, eyestrain, dry eyes, and irritated eyes. The results concerning the impacts of digital devices on blink rate are ambiguous, which may be related to task difficulty, which also contributes to a decrease in blink rate. While the impact of mobile phones on blink frequency has not yet been researched, tablet use may lead to more incomplete blinks. On the contrary, the usage of computers has been proven to affect both blink rate and amplitude. The usage of handheld digital devices, as well as laptops, may have an unfavorable effect on tear stability. Even though there seems to be a correlation between computer use and tear volume, there is not enough research to support this. Other ocular surfaces and tear function markers have yet to be studied in conjunction with smartphone or tablet use. Users are increasingly using numerous digital devices simultaneously, such as tablets, phones, and computer displays. This refers to double or triple screening. It is unclear whether using several gadgets significantly affects the visual system and eye surface, and it is also unclear how moving among screens affects accommodation and vergence.

Acknowledging the ocular and visual consequences of smart mobile phones and handheld digital device use is critical for formulating healthcare instructions to reduce user eye pain. In addition, such knowledge would also help design digital gadgets to reduce the possibility of visual and ocular pain in the general public.

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