ORIGINAL ARTICLE

Assessment of Visual Fatigue While Watching Digital Screens

Mubashir Rehman[1], Faisal Khan [1], Jahanzaib Khan[1], Adnan Ahmad[2], Mohammad Zeeshan Tahir [2].

ABSTRACT

Aim: To correlate visual fatigue such as eye tiredness and headache with the use of digital screens.

Study design: Observational Study

Duration and Setting of the Study: Department of Ophthalmology, Qazi Hussain Ahmad Medical Complex, Nowshera from 1 Jan 2022 to 31 Dec 2022.

Methods: A total of 101 general population data was collected. All patients were inquired about using screens at different distances, brightness, exposure time, and by using spectacles or screens with or without filters. Their records were analysed for fatigue caused due to watching screens. Data was entered and analysed for simple percentages using SPSS version 25.0.

Results: Smartphone was used mostly with 80.19%. Exposure time to screens was 4 hours in 31.68% and 6 hours in 33.66% of study participants. Exposure time to smartphones was 4 hours in 26.73% of participants and 6 hours in 26.73%.of participants. Amongst the participants, 90.09% were screen users at near distance, out of which 73 (72.27%) smartphone users complained of eye tiredness. Seventy-eight people were using smartphones at high brightness which caused visual fatigue in 77.22% of participants. Sixty Seven (65.85%) were using screens at a close distance which caused eye tiredness with a percentage of 67.89%. The chi-square test showed a significance value in two groups ($p<0.05$).

Conclusion: Visual fatigue occurred when exposure to screens was more than 4 hours. The use of screens close to the eyes with high brightness caused a decrease in the blinking rate that resulted in asthenopia, dry eye, computer vision syndrome, and eye tiredness.

Keywords: Visual fatigue, Smartphone, Digital screen.

INTRODUCTION

The use of digital devices has increased considerably in recent years across all age groups. Extensive daily use is now normal for both social and professional purposes.[1] Smartphones are friendly gadgets with emerging technology in the current generation which has made everything accessible with a single touch. They occupy massive space in our daily lives.[2]

Digital eye strain (DES), also known as computer vision syndrome, includes a range of ocular and visual symptoms, and estimates suggest that its prevalence may be 50% or more among computer users.[3] The expected number of smartphone users worldwide was approximately seven billion in the year 2019[2] and in 2020 the observed number of smartphone users is approximately 3.5 billion worldwide, this showed that 45.15% of the world population used their smartphones.[4]

Constant staring at the screen leads to certain health discomforts like migraines, dark circles around the eyes, weak eyesight, and ocular pain.[5] Common visual symptoms include dryness and irritation, sensations of burning, asthenopia, epiphora, hyperemia, blurred vision diplopia, and glare sensitivity.[6] Other extra ocular complaints associated with CVS frequently include musculoskeletal pain in the neck, back, and shoulders.[7] It also affects focus, and attention and creates functional impairments to the users and it disturbs our brain as well, leading to visual, mental, and

Correspondence
Mubashir Rehman
drmubashirrehman78@gmail.com
House No: L/68 Mohallah Gari Saidan inside
Hushtnagri gate, Peshawar, Pakistan

[1]Department of Ophthalmology Nowshera Medical College / Qazi Hussain Ahmad Medical Complex, Nowshera, Pakistan

[2]Department of Ophthalmology, Gajju Khan Medical College/ Bacha Khan Medical Complex, Swabi, Pakistan.

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ocular fatigue.[6]

Visual asthenopia means an eye without power which is an overall investigative term used for visual tiredness and visual discomfort.[8] Asthenopia mostly occurs as an overall headache, or it may cause pain in the neck and shoulder region.[9] Eyestrain is nearly identical with the objective component of asthenopia i.e. visual fatigue. Visual fatigue is defined as a physiological strain or a strain of the visual system as it causes ineffective changes, as well as conflicting or problematic, functional, and adaptive states of the visual system. Indicators to measure visual tiredness and visual discomfort are various and widespread.[10] However, they can be divided into two types of indicators i.e. objective indicators of visual tiredness and subjective indicators of visual comfort.[11]

The blue light technology of smartphone screens increases fatigue level, which disturbs sleeping, causes weakness, reduced or double vision, ocular pain, headache, melatonin reduction, and many other health problems.[12] The absorption of blue light is higher in young than others, due to the usage of smartphones for a long time and maintaining a shorter distance between smartphones.[13] Blue light disturbs the circadian rhythm of life causing disturbance in sleep by inhibiting melatonin production; promoting alertness, visual fatigue and causes asthenopic symptoms like headache, and ocular pain.[12]

Different types of display devices are associated with unique profiles of visual effects, which might be due to different viewing positions (distance and angle), patterns of use, screen resolution and contrast, image refresh rates, screen glare, colour spectra, and other digital features.[14]

The objectives of our study were to check the correlation between eyestrain and duration of screen exposure, to determine the relationship between the eyestrain and viewing distance, to check the correlation between eyestrain and level of brightness, and to determine the visual fatigue in screen users without using proper anti-blue filters.

METHODS

It was a cross-sectional descriptive study conducted at the Department of Ophthalmology, Qazi Hussain Ahmad Medical Complex, Nowshera from 1st Jan 2022 to 31st Dec 2022. A total of 101 patients were selected through a non-probability consecutive sampling technique using the formula n= z2 1-α2p (1-p) d2 where α=Confidence level = 95%, z=standard normal variate (for α =95%, z =1.96), d=Level of precision = 0.05, p=Population proportion =7%

Patients were selected from both genders with age ranging from 15 to 50 who were screen users (smartphone and computer). Subjects using smartphones and computers having other diseases of the eyes e.g. allergic conjunctivitis, blepharitis, and dry eye syndrome due to other reasons were excluded from the study. Data was collected through a designed questionnaire including duration of exposure to the screen, the distance between the screen and the subject, brightness levels while watching the screen and watching screens with or without filters. Asthenopic (eye tiredness) symptoms and eye fatigue level were measured by asking the subjects to mark eye tiredness from strongly agree to disagree or not sure at all. Data was entered and analysed through SPSS version 25.0. Quantitative data was measured by percentages, frequency, and standard deviation of variables. The statistical significance level P was less than 0.05.

RESULTS

Most of the screen users were in the age group 15 to 35 years which was 80 (79.2%) while it was less common above 36 years of age which was only 21(20.8%). Out of 101 subjects, 54 (53.47%) were

males and 47(46.53%) were females. Out of 101, 81(80.19%) were mainly using smartphones, laptops 6 (5.94%), computers used by 8 (7.92%), and all gages were used by 6 (5.94%) of patients. About one-third (33.66%) of the participants were using screen for six hours while 31.68% of participants were screen users for four hours. Eighty one patients were using smartphones mostly and daily using time for smartphones was 4 hours (26.73%) and 6 hours 26.73%) with a total percentage of 53.46%. Detail are presented in table 1.

Table 1: Exposure to screens time

	2hours	4hours	6hours	More than 6hours	Total
Smartphone	9 (8.91%)	27 (26.73%)	27 (26.73%)	18 (17.82%)	81 (80.19%)
Laptop	0	2 (1.98%)	3 (2.97%)	1 (0.99%)	6 (5.94%)
Computer	1 (0.99%)	2 (1.98%)	3 (2.97%)	2 (1.98%)	8 (7.92%)
All	0	1 (0.99%)	1 (0.99%)	4 (3.96%)	6 (5.94%)
Total	10 (9.99%)	32 (61.68%)	34 (33.66%)	25 (24.75%)	101

%= percentage

About 90.09% (51.48% strongly agree, 38.61% agree) were screens users out of which,73 were using smart phones close to their eyes which causes eye tiredness with a percentage of 72.27% (42.57% strongly agree, 29.70% agree) Table 2. Applying the Chi-square test, showed a significance value in two groups. (p=0.002).

Table 2: Fatigue caused while watching screens close to eye.

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
Smart phone	43 (42.57%)	30 (29.70%)	3 (2.97%)	4 (3.96%)	1 (0.99%)	81 (80.19%)
Laptop	2 (1.98%)	3 (2.97%)	0	1 (0.99%)	0	6 (5.94%)
Computer	4 (3.96%)	3 (2.97%)	0	1 (0.99%)	0	8 (7.92%)
All	3 (2.96%)	3 (2.96%)	0	0	0	6 (5.94%)
Total	52 (51.48%)	39 (38.61%)	3 (2.97%)	6 (5.94%)	1 (0.99%)	101

%=percentage, Chi-square test, showed significance value in two groups.(p=0.002)

Most people used smartphones at high brightness. Out of 81, 78 smartphone users feel eye tiredness at high brightness with a percentage of 78.22% (34.65% strongly agree, 42.57% agree) High brightness decreases blinking frequency rate resulting in evaporation of tears causing dry eye and eye tiredness (Table 3). Chi-square value is p=0.030 which is <0.05, so there is a statistically significant difference between feeling of eye tiredness at high brightness in various gadgets.

Table 3: Brightness level while using screen

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
Smart phone	35 (34.65%)	43 (42.57%)	1 (0.99%)	1 (0.99%)	1 (0.99%)	81 (80.19%)
Laptop	4 (3.96%)	2 (1.98%)	0	0	0	6 (5.94%)
Computer	4 (3.96%)	3 (2.97%)	0	1 (0.99%)	0	8 (7.92%)
All	4 (3.96%)	1 (0.99%)	0	0	1 (0.99%)	6 (5.94%)
Total	47 (46.53%)	49 (48.51%)	1 (0.99%)	2 (1.98%)	2 (1.98%)	101

Chi square value is p=0.030

Amongst the participants, 65.85% (24.75% with strongly agree and 41.10% with agree) are screen users out of which, 55 are using smartphone or spectacles without an anti-reflective coating which cause eye tiredness with a percentage of 67.89% (28.39% strongly agree and 39.50% agree) Table 4). Chi-square test showed a significance value in two groups. (p=0.001).

Table 4: Watching screens without proper anti-reflective coatings

	Strongly agree	Agree	Uncertain	Disagree	Strongly disagree	Total
Smart phone	23 (28.39)	32 (39.50%)	9 (11.11%)	14 (17.28%)	3 (3.70%)	81 (80.19%)
Laptop	0	5 (4.95%)	1 (0.99%)	0	0	6 (5.94%)
Computer	1 (0.99%)	4 (3.96%)	2 (1.98%)	1 (0.99%)	0	8 (7.92%)
All	1 (0.99%)	1 (0.99%)	3 (3.70%)	1 (0.99%)	0	6 (5.94%)
Total	25 (24.75%)	42 (41.10%)	15 (14.85%)	16 (15.84%)	3 (3.70%)	101

%=Percentage ,Chi-square test showed significance value in two groups. (p=0.001)

DISCUSSION

Many image systems have been studied for a long time including stereoscopic images. In stereoscopic imaging, huge improvements have been made in display technology and picture quality has also been improved with an increase in technical progress.[15] However, although image hardware has advanced, image presentation for the human visual system remains insufficient. Efforts that have been made are not enough to reduce visual fatigue and eye strain for the viewer. In a stereoscopic image, the viewer watches two images corresponding to the right and left eyes with inward eye movement, which allows the two images of

a single object to fuse. As a result, rivalry occurs between convergence or divergence eye movement which results in visual fatigue.[16]

Computer vision syndrome, also known as digital eye strain, is the combination of eye and vision problems associated with the use of computers and other electronic displays. Today, many individuals spend a lot of time viewing these screens. However, the visual demands differ significantly from those presented by traditional printed materials, with the result that up to 80% of users report significant symptoms both during and immediately after viewing electronic screens.[17] this study analyses the principal ocular causes for this condition and discusses how the standard eye examination should be improved to meet today's visual demands.

This study evaluated vision distance and symptoms of eye tiredness in a group aged 15 to 50 years who are using screens for many hours. Results show that among different screen users, the exposure to smartphones is more than 80.20% at different hours of the day. The results obtained show that most people's exposure time to screen is 4 hours (31.68%) and 6 hours (33.66%) among which smartphone exposure is more and as a result the eye tiredness symptoms increased and the same after watching the smartphone for 4 hours (26.73%) and 6 hours (26.73%) with a total percentage of 53.46%. The comparison of different devices shows that smartphone user shows more fatigue of eyes than others with a percentage of 72.27%. Comparable results were found in a study conducted by Straker, et al in 2018.[18]

Regarding distance to eyes, 51.48% strongly agree and 38.61% agree are using screens close to the eye. The result obtained for smartphones shows that out of 81,73 used smartphones close to their eyes which caused eye tiredness with a percentage of 72.27% (42.57% strongly agree and 29.70% agree p=0.002). The indication scores presented that the greatest rise after the 4 hours of watching the smartphone continuously were tired eyes, uncomfortable eyes, and fuzzy eyes. Priya and Subramaniyam showed in their rise study that rise in symptoms of "eye discomforts" was minimal when using a screen at an intermediate distance.[2]

People accept closer distance when viewing small characters and obviously, the trouble for visual examination assignment is greater when watching small characters.[18,19] Brennan et al reported in their study that the subjective relief assessments are reduced in the incidence of visual strain related to watching screens near to eyes and by small lines.[14]

Koo and co-authors showed in their study that visual fatigue is caused by high brightness level during prolonged use of digital screens.[9] Our results showed that the majority of subjects were sensitive to visual fatigue by watching screens at high brightness. The result also shows that reading under a high brightness level leads to a decrease in the frequency of blink rate with respect to a low brightness level. A high level of brightness is usually associated with a decrease in blinking frequency and increased tear evaporation rate leading to dry eye, one of the main factors of visual fatigue.[20,21] In our study out of 81,78 smartphone users were feeling eye tiredness at high brightness with a percentage of 77.22%(34.65% strongly agree and 42.57% agreep=0.030).

With the improvement of lifestyle, the exposure to screen and light are more nowadays. Ide, et al recommended in their study that it is need of the hour to prevent the blue light coming from screens, an anti-blue light effect is used over the screen to prevent them.[22] Here in this study,65.85% (24.75% with strongly agree and 41.10% with agree) are screen users without proper anti-reflecting coating and for smartphone out of 81, 55 are using smartphone or spectacles without an anti-reflecting coating which cause eye tiredness with a total percentage of 67.89% (28.39% strongly agree and 39.50% agree p=0.001). Bang, et al recommended that different eye exercises, low brightness level and anti-reflective coatings of screens will help in relieving visual fatigue and eye strain.[23]

On the basis of the results of our study we suggest the following recommendations for screen users: Always

use screens for a short time because too much exposure to screens can cause asthenopic symptoms and certain eye conditions like dry eye syndrome and computer vision syndrome. Always maintain a proper distance between eyes and screens to avoid eye tiredness. The recommended distance for smartphone user is about 16 to 18 inches while for computer this distance should be roughly between 45-70 cm and ideally 60 cm. Always use the right amount of brightness while using screens. The brightness level should be intermediate. Always use anti-blue light filters over screens or spectacles to avoid certain eye conditions. Always follow 20,20,20 rules, according to which using screens for 20 minutes look at 20 feet for 20 seconds.

Conclusion:

Exposure to screens for more than 4 hours, without anti-reflecting coating over screens or spectacles at close distance with high brightness causes a decrease in blinking rate, increases evaporation of tear film leading to asthenopic symptoms, dry eye, computer vision syndrome, and eye tiredness. Spending more hours using smartphone has adverse effects on the eyes as well as personality, behaviors, and social gathering.

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