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Original Article

Ophthalmology Section

Smartphone Vision Syndrome Associated with Prolonged Use of Digital Screen for Attending Online Classes during COVID-19 Pandemic among Medical Students: A Cross-sectional Study

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ABSTRACT

Introduction: Smartphone vision disorder is a complex of eye and vision related problems associated with close work during use of digital screen. It is one of the rising wellbeing concerns identified with innovation (phones and tablets) because of constant utilisation of Smartphones among medical undergraduates particularly during the last five months due to COVID-19 pandemic for attending online classes.

Aim: To investigate the impact of online classes on development of Digital Vision Syndrome (DVS) among undergraduate medical students.

Materials and Methods: A cross-sectional study was conducted in 280 undergraduate medical students from 1st and 2nd professional MBBS course attending online classes regularly from the last five months. The authors evaluated the student's perception based on the symptoms experienced in the last five months through a pre-tested questionnaire related to DVS which are caused due to two mechanisms: (i) accommodative mechanism; (ii) ocular surface mechanism by using 5-point Likert scale. The association between development of DVS symptoms and risk factors like distance of eyes from the screen, refractive errors, duration of exposure and size of screen was analysed by factor analysis and ANOVA through EpiInfo™ for windows version 7.2.4.

Results: In the present study, 78.2% of students were using smartphones and 21.8% were using large screen for reading and attending online classes during the lockdown period. It was observed that the descriptive statistics elaborates the overall mean of approximately score 3 in all 280 students on Likert scale. In regard to distance at which digital screen was kept, students who kept less distance (> arm and forearm length) are at higher risk of DVS development ($p<0.001$). In case of refractive error, the negative correlation shows that impact with spectacles is less compared to emmetropic eye ($p<0.01$ and $p<0.001$). About 75% of the total students score range between occasionally to always which indicates that the majority of the students got DVS. Authors assess the impact of duration of digital screen used and revealed that accommodative and ocular mechanisms responsible for development of DVS were significantly affected as duration of exposure to digital screen increases ($p<0.001$). We analysed the impact of digital screen size on DVS symptoms and found that participants using small screen are at higher risk ($p<0.001$) for development of smartphone vision syndrome as compared to large screen digital devices.

Conclusion: The students attending online classes are more prone to development of smartphone vision syndrome. This study had shown association between DVS and the risk factors associated with it: duration of exposure, distance from the screen and size of screen used.

Keywords: Digital eye strain, Lock down period, Ocular mechanisms, Online teaching

INTRODUCTION

In the COVID-19 era, online lecture plays a major role in education system for learning and development of medical students as well as in other fields too. During this pandemic, medical education and lot other fields accustomed to utilise technology to another level. For the learning process students are more dependent on digital devices like smartphones and laptops. DVS is a complex of eye and vision problems related to near activities performed on digital screen [1]. More frequent use of PC and small tiny screens bring about Digital Eye Strain (DES). This is related to the stress on the near vision during the utilisation of digital screens [2,3]. The use of PCs and digitals screen for over three hours increases the risk of DVS [4].

The important features of DVS are eyestrain, headache, dry eye sensation, blurred vision, tearing, burning of eyes, watering of eyes, photophobia, red eyes, burning, itching and sometimes ocular pain [5,6]. Few researchers ordered this manifestations relying upon expected mechanisms into three classes like visual, extra visual and accommodative [2,7]. The associated risk factors responsible for development of DVS could be alteration in blinking frequency, uncomfortable posture, staring continuously at the digital screens for study, improper illumination, refractive error and inaccurate distance between eye and digital screen as well as size of digital screen i.e., tiny v/s large screen [8-10].

In reality, a few studies detailed DVS as a significant issue related with long haul visual and musculoskeletal whines that influences the health of the eyes and the body. Moreover, DVS impacts badly on life style, work and family connections [11,12]. Numerous authors recommended a few measures to treat or if nothing else mitigate the seriousness of DVS consequences [13,14].

Social media like WhatsApp, Twitter, Facebook, chatting, use of smartphones by students is increasing day-by-day. For a lot of literature is available about the prevalence of DVS in students, employers of different fields using computer i.e., large screen and positive impact was observed between use of computer and DVS syndrome [4,15,16]. However, hardly any study has been

done on the effect of tiny digital screen usage on smartphone vision syndrome particularly during COVID-19 pandemic period during which medical students all over the world are forced to attend online classes regularly with minimum 2-3 hours/day and they have to depend on digital screens to attend online classes and also for reading the topics covered through soft copies, so Authors assess the impact of smartphone use on ocular symptoms and correlating the risk factors associated with development of smartphone vision syndrome.

MATERIALS AND METHODS

The cross-sectional study was initiated during lockdown period in the month of April 2020 and after attending online classes for five months, in the month of August 2020. The institution ethical approval was obtained from the Institutional Ethics Committee (Redg. No. ECR/1192/Inst/MP/2019). The present study was carried out in a new medical college running in second year and only two batches available with a total strength of 330 students attending classes through online mode from the last five months during COVID-19 pandemic.

Inclusion and Exclusion criteria: Students who had equal to or more than 80% attendance were included in the study. Students having any eye disorder, using eye drops frequently and those who are not able to attend online classes regularly due to network issues, inadequate mobile data, not having smartphones, electricity issues were excluded from the study.

Total of 280 undergraduate medical students from 1st and 2nd professional between age group of 18-25 years were selected for the study out of which 135 were girls and 145 were boys. After full explanation of the structured questionnaire form through online mode, students were provided a Google form with a pre-designed and pre-tested anonymous student feedback questionnaire (Annexure attached) by sending a link through WhatsApp and asked to fill the form and submit it within one hour. Students responded to the questions measuring their perception based on the symptoms experienced in the last 5 months related to DVS which are caused due to two mechanisms: (i) accommodative mechanism; (ii) ocular surface mechanism. The data were collected which includes demography, refractive errors, duration of exposure to digital screen utilised only for reading and attending online lectures during COVID-19 pandemic as well as the size of screen used during learning process.

Measures

The authors measured students' overall perceptions of ocular symptoms through questions which are based on two potential mechanisms such as accommodative mechanism and ocular surface mechanism. Authors used Likert 5 point scale (never, rarely, occasionally, frequently, always) to measure students' perceptions of ocular symptoms. The research questions which were measured were:

Accommodative mechanism: We measured students perception related to accommodative mechanisms responsible for development of smartphone vision syndrome by using a five-point Likert scale which includes five items like blurring, eye straining, heaviness in the eyes, tiredness and headache. A higher mean score indicates students' perception for development of smartphone vision syndrome based on the symptoms experienced related to accommodative mechanisms after using a digital screen for attending online classes and study.

Ocular surface mechanism: Ocular surface mechanisms like redness, burning sensation, watery eyes and ocular pain were measured by using a 5-point Likert scale and interpreted that high mean score leads to progression towards DES.

The association between development of ocular symptoms and risk factors like distance of eyes from the screen and refractive errors was analysed. Authors also analysed the impact of duration (1-3 hrs/day, 3-5 hrs/day and more than 5 hrs/day) of digital screen usage on the development of smartphone vision syndrome as well as we assessed the impact of size of digital screen (laptop/computer screen vs smartphone) on development of smartphone vision syndrome.

STATISTICAL ANALYSIS

Both mechanisms were compared using Exploratory Factor Analysis (EFA) to observe item loading patterns. Descriptive statistics were used for the data screening analysis and found to be acceptable, that is, they had an acceptable reliability (Cronbach's alpha >0.6). The reliability and Content Validity Index (CVI) analysis was carried for accommodative mechanism and ocular mechanism out on the scale comprising five and four items respectively. Cronbach's alpha showed the questionnaire to reach acceptable reliability, α=0.889 and CVI is 0.721 for accommodative and α=0.812 and CVI is 0.769 for ocular mechanism and both are satisfactory. Kaiser-Meyer-Olkin measure of sampling adequacy is 0.829 and 0.789 which is rated very high for both mechanisms. Sampling adequacy was found to be good. Bartlett's test of sphericity was used to test the null hypothesis - that the variables in the population matrix were uncorrelated. Both samples had a significance level of $p<0.001$, indicating that the hypothesis was rejected, and meaning that the strength of the relationship among variables was strong. It was thus suitable to proceed to factor analysis for the data.

RESULTS

Total 280 students participated in the present study with mean age (20.36±1.30) between 18-25 years, out of which 219 students were using smartphones for reading and attending online classes and 61 students were using large screen. In [Table/Fig-1], the descriptive statistics data are means±SD (n=280). A higher item score (range 1-5) indicated the severity. The data analyzed were scored as 1=Never, 2=Rarely, 3=Occasionally, 4=Frequently, and 5=Always. As per the response of the individual students "Never"=1%, "Rarely" =24%, "Occasionally"=46%, "Frequently"=24% and "Always"=5%. About 75% of the total students score range between occasionally to always which indicates that the majority of the students got DVS.

	Variables	Mean	SD
Accommodative mechanism	1 Blurring	2.46	0.95
	2 Eyes strained	3.18	1.27
	3 Eyes feeling heavy	3.69	1.04
	4 Tiredness	3.72	0.95
	5 headache	3.28	1.12
Ocular surface mechanism	6 Redness in the eyes	2.68	1.27
	7 Burning sensation	2.63	1.15
	8 Watery eyes	2.83	1.20
	9 Ocular pain	2.78	1.24

[Table/Fig-1]: Descriptive statistics of different accommodative and ocular surface mechanism responses. (n=280).

[Table/Fig-2] presents a correlation matrix which shows the significance ($p<0.001$) in both the cases. The correlation of all items in the ocular mechanism shows better association and in accommodative mechanism except blurring, other shows better association.

In [Table/Fig-3], (184 and 96) a one factor solution was supported by the percentage of variance accounted for by each factor. In both cases, the factor accounted for 57% and 64% of the variance. The second factor in both cases accounted only for an additional 14% each of the variance, and subsequent factors independently accounted for progressively lower percentages of variance.

As most of the participants were using smartphone for online academic activities during lockdown period, 184 students were visualising the digital screen from distance less than arm and

Accommodative mechanisms		Blurring	Eye strained	Eyes filling heavy	Tiredness	Headache
Correlation (r-values)	Blurring	1.000	0.411	0.327	0.430	0.429
	Eye strained	0.411	1.000	0.482	**0.522**	**0.499**
	Eyes filling heavy	0.327	**0.482**	1.000	**0.583**	**0.476**
	Tiredness	0.430	**0.522**	**0.583**	**1.000**	**0.483**
	Headache	0.429	**0.499**	**0.476**	**0.483**	1.000
Sig. (1-tailed) (p-values)	Blurring		0.001	0.001	0.001	0.001
	Eye strained	0.001		0.001	0.001	0.001
	Eyes filling heavy	0.001	0.001		0.001	0.001
	Tiredness	0.001	0.001	0.001		0.001
	Headache	0.001	0.001	0.001	0.001	
Ocular mechanisms		**Redness**	**Burning**	**Watery**	**Ocular**	
Correlation (r-values)	Redness	1.000	**0.619**	**0.509**	0.507	
	Burning	**0.619**	1.000	**0.509**	**0.531**	
	Watery	**0.509**	**0.509**	1.000	**0.450**	
	Ocular	**0.507**	**0.531**	**0.450**	1.000	
Sig. (1-tailed) (p-values)	Redness		0.001	0.001	0.001	
	Burning	0.001		0.001	0.001	
	Watery	0.001	0.001		0.001	
	Ocular	0.001	0.001	0.001		

[Table/Fig-2]: Correlation matrix for accommodative and ocular mechanisms.

Component	Initial Eigen values			Extraction sums of squared loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
Blurring	2.865	57.309	57.309	2.865	57.309	57.309
Eye strained	0.698	13.970	71.279			
Eyes filling heavy	0.537	10.743	82.022			
Tiredness	0.501	10.029	92.051			
Headache	0.397	7.949	100.000			
Redness	2.566	64.149	64.149	2.566	64.149	64.149
Burning	0.552	13.802	77.951			
Watery	0.503	12.564	90.515			
Ocular	0.379	9.485	100.000			

[Table/Fig-3]: Total variance explained for accommodative and ocular mechanism.
Extraction Method: Principal Component Analysis

forearm length while 96 students from distance greater than arm and forearm length. [Table/Fig-4] presents correlations in both the parameters (accommodative and ocular surface mechanisms) with the different dependent variables such as distance from the screen and refractive errors was analysed in which distance from the screen and different accommodative and ocular mechanisms responsible for DVS have not shown strong correlation but they show the positive and negative correlation with each symptoms related with DVS and correlations were significant ($p<0.01$ and $p<0.001$).

Out of 280 participants, 75 were reading for 1-3 hours, 144 for 3-5 hours and 61 for more than 5. Prevalence of ocular symptoms depending on duration of exposure to screen was calculated by ANOVA and the calculated value of F is greater than tabulated. It means the variability observed in these durations per day use of digital platform only for reading and attending lectures online in the last 4-5 months are not by chance and it can be attributed to the effect of duration and it represents that effect on the eyes increases as duration increases [Table/Fig-5]. In [Table/Fig-6], with regard to size of screen associated with DVS symptoms, calculated value of F is greater than tabulated. It means the variability observed in these small and large screen groups are not by chance and it can be attributed to the effect of the small screen on the eyes more than the large screen.

Pearson correlation coefficient			
	Variables	Distance from screen	Refractive error
Ocular surface mechanism	Redness in the eyes	0.20**	-0.05
	Burning sensation in your eyes	0.03	-0.18*
	Watery eyes	0.10*	-0.11*
	Ocular pain	0.05	-0.19**
Accommodative mechanism	Blurring	0.004	-0.20**
	Eyes strained	0.134**	-0.20**
	Eyes feeling heavy	0.23**	-0.17**
	Tiredness	0.15*	-0.30**
	Headache	0.10*	-0.16**

[Table/Fig-4]: Pearson correlation-coefficient and significance test among different accommodative and ocular mechanism vs distance from the screen and Refractive error (n=280).
*Correlation is significant at the 0.01 level (2-tailed).
**Correlation is significant at the 0.001 level (2-tailed)

ANOVA depending on exposure to the screen						
Source of variation	SS	df	MS	F	p-value	F crit
Rows	30003.85185	8	3750.481	6.973556	0.000519	2.591096
Columns	27880.2963	2	13940.15	25.91998	9.57E-06	3.633723
Error	8605.037037	16	537.8148			

[Table/Fig-5]: ANOVA of different accommodative and ocular surface mechanism depending on duration of exposure.
SS: Sum of squares; df: Degree of freedom; MS: Mean square; F: F ratio; F crit: F-critical value

ANOVA depending on size of the screen						
Source of variation	SS	df	MS	F	p-value	F crit
Rows	36762	8	4595.25	2.517984	0.000819	3.438101
Columns	99606.72222	1	99606.72	54.57986	7.70891E-05	5.317655
Error	14599.77778	8	1824.972			

[Table/Fig-6]: ANOVA of different accommodative and ocular surface mechanism depending on size of the screen.

DISCUSSION

Eye strain due to continued digital screen viewing has become a worldwide problem. This is accompanied by an increase in our dependance on portal and handheld digital screens. In fact, smartphones have become so popular in adolescence that right from school going age an individual has at least one or more of these digital devices. The usage of social media has increased exponentially to disturbing levels. But in the last five months due to COVID-19 pandemic, students all over the world including medical students have been forced to attend classes through online mode which has increased additional load on the eyes for learning and reading purposes. So, the purpose of this study was to evaluate the impact of online usage of digital screens in undergraduate medical students from Ist and IInd year attending online classes and the risk of developing of smartphone vision syndrome during COVID-19 Pandemic. In younger age groups the strain is lesser while reading printed material when compared to digital screen [17]. The present study showed 75% of the students perceived the overall ocular symptoms as measured on Likert scale. Thus was similar to the previous study by Iqbal M et al., which showed 86% of medical students using digital screen to suffer from one or more of CVS manifestations [7]. Another study by Akinbinu T and Mashalla Y, showed the impact of digital screen usage for more than 3 hours to develop one or more symptoms of CVS in bank employees [18].

The correlation indicates that the students keeping the screen close to eyes (less than arm and forearm length) are prone for the development of DVS and the students keeping the screen at distance (more than arm and forearm length) are less prone to develop DVS. In case of refractive error, the negative correlation shows that

the students wearing spectacle (n=150) are less associated with DVS and students with emmetropic eyes (n=130) are significantly associated with DVS.

With regard to distance at which digital screen was kept while attending online classes and reading soft copy, students who kept less distance (less than arm and forearm length) are at higher risk of smartphone vision syndrome development. This association in respect to accommodative and ocular mechanisms agrees with the findings shown by Abudawood G et al., and Rosenfield M, [4,12]. In the present study, refractive errors showed no significant association with DES as shown in previous studies by Abudawood G et al, [4]. However the impact of wearing glasses due to ocular complaints in the study was found to be less than those students who were emmetropic. This could be due to less use of accomodative mechanisms in students wearing glasses while using digital screens. A similar report was also shown by Raja AM et al., who found that ocular complaints were more in the subjects without glasses [19].

As students are using the digital screens regularly for online classes, we assess the duration of digital screen used and revealed that accommodative and ocular mechanisms responsible for development of smartphone vision syndrome was significantly affected as duration of exposure to digital screen increases which was also reported by Bergqvist UO et al., Hassan HMJ et al., Noreen K et al., and Shantakumari N et al., [15,20-22].

However, ocular pain is a symptom commonly related to raised intraocular pressure and glaucoma, It is possible that this symptom could be due to tightness of the eyelid from dry eye. However, the chance of an actual increase in IOP cannot be debarred since the close viewing of small text on a small screen (as during smartphone use) increases the accommodation demands [23] which are linked with an increase in IOP [24,25].

Limitation(s)

This study was a cross-sectional investigation performed in a single institute with the ocular complaints analysed based on student response without any opthalmic examination.

CONCLUSION(S)

This research was conducted in a pandemic time where medical education forced globally to shift to online teaching mode which puts additional load on eyes for attending online classes regularly from the last 5 months. The results indicated that the students attending online classes are more prone to development of smartphone vision syndrome. This study had shown association between DVS and the risk factors associated with it: duration of exposure, refractive errors, distance from the screen and size of screen used. The overuse of smartphone could be precursor of raised intraocular pressure and irreversible loss of vision due to glaucoma need to evaluate furthermore in larger group and in longer duration of study. As colleges constantly build up their instructive strategies, there is a need to raise mindfulness students to understand the impact of digital screen viewing for long duration. This will help in preventing the risk of developing smartphone vision syndrome.

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ANNEXURE

Questionnaire on the perception of smartphone vision syndrome

A) Research question 1 :- Demography

1. Age : 18 19 20 21 22 23 24
2. Sex : male female

B) Questionnaire on the dependant variable

1. Type of digital screen used by me for attending online classes and reading during lockdown period
   Laptop Smartphone Computer
2. How many hours in total do you spend on Digital screen only for reading/studying/ attending lectures?
   1-3 hrs 3-5 hrs more than 5 hrs
3. Do you have any refractive error ? If yes, mention the power of your glass (with spherical or cylindrical lens)
   No Yes (mention the power)
4. At what distance your computer screen is while reading/ attending classes during the lockdown period?
   >Arm and forearm length <Arm and forearm length

C) Smartpnone vision syndrome feedback form

Q-1. Do the letters on the screen become blurred when reading on the Computer/Laptop/Mobile?
Never Rarely Occasionally Frequently Always

Q-2. Do your eyes feel tired during or after reading on the computer/Laptop/Mobile?
Never Rarely Occasionally Frequently Always

Q-3. Have you suffered watery eyes daily during or after attending online classes or reading through digital screens?
Never Rarely Occasionally Frequently Always

Q-4. Do your eyes feel heavy after reading on the Digital screen for some time?
Never Rarely Occasionally Frequently Always

Q-5. Do you ever get a burning sensation in your eyes?
Never Rarely Occasionally Frequently Always

Q-6. Do you need to strain your eyes to see well after spending time on the compute/laptop/mobile?
Never Rarely Occasionally Frequently Always

Q-7. Have you noticed redness in the eyes after spending 4-5 months for reading on the computer/laptop/mobile?
Never Rarely Occasionally Frequently Always

Q-8. Do you feel any ocular pain during/after reading on the computer/laptop/mobile?
Never Rarely Occasionally Frequently Always

Q-9. Do you feel headache during or after reading/attending classes on the computer/laptop/mobile?
Never Rarely Occasionally Frequently Always