Archives of the Balkan Medical Union
vol. 59, no. 1, pp. 23-30
March 2024
Copyright © 2024 Balkan Medical Union

ORIGINAL PAPER

A CROSS-SECTIONAL SURVEY OF THE EFFECTS OF DIGITAL SCREENS ON THE VISION OF ADOLESCENTS

Tundzhay R. YOZTYURK[1], Kiril S. SLAVEYKOV[2], Kalina Z. TRIFONOVA[1]✉

[1] Medical Faculty, Trakia University, Stara Zagora, Bulgaria
[2] Medical Faculty, Stara Zagora,Trakia University, Bulgaria

Received 14th Dec 2023, Accepted 11th Jan 2024
https://doi.org/10.31688/ABMU.2024.59.1.03

Abstract

Introduction. Digital eye strain is a new clinical syndrome that affects any person who spends a large period of time fixed on multiple screens, for work or leisure.
The objective of the study was to analyze the effects of using different digital devices on the visual system of adolescent school children.
Material and methods. One hundred questionnaire were handed out in two outpatient ophthalmic clinics in Stara Zagora and Kazanlak, Bulgaria, to high school students aged between 13 and 18 years. From these questionnaires, 82 were fit for analysis and were used in our study. SPSS 19 was used for statistical analysis.
Results. The results showed that only 3.7% of adolescents did not use a smartphone and 75.6% of them spent more than two hours a day using one. 72% of the participants had at least two or more symptoms of digital eye strain. The most commonly reported symptoms were headache (65.9%), eye strain (54.9%) and blurred vision (53.7%). The time spent using a smartphone was strongly associated with eye redness and had positive correlation with the frequency and severity of burning, eye strain, blurred vision, double vision, photophobia, heavy eyelids, eye pain and difficulty focusing. Females had more symptoms of digital eye strain compared to male participants. Mild headaches

Résumé

Une étude transversale des effets des écrans numériques sur la vision des adolescents

Introduction. La fatigue oculaire numérique est un nouveau syndrome clinique qui touche toute personne passant une longue période devant les écrans.
L'objectif de l'étude a été d'analyser les effets de l'utilisation de différents appareils numériques avec un écran, sur le système visuel des adolescents.
Matériel et méthodes. 100 questionnaires ont été distribués dans deux cliniques ambulatoires d'ophtalmologie à Stara Zagora et Kazanlak, en Bulgarie, à des écoliers âgés de 13 à 18 ans. Au total, les résultats de 82 questionnaires étaient suffisamment exploitables et ont servi pour notre étude. Nous avons utilisé SPSS 19 pour l'analyse statistique.
Résultats. Les résultats ont montré que seulement 3,7% des adolescents n'utilisaient pas de smartphone et que 75,6% d'entre eux passaient plus de deux heures par jour à en utiliser un. Mais également, 72% des participants présentaient au moins deux symptômes de fatigue oculaire numérique. Parmi les symptômes les plus fréquemment constatés, étaient les maux de tête (65,9%), la fatigue oculaire (54,9%) et la vision floue (53,7%). Le temps passé à utiliser un smartphone était fortement associé à la rougeur des yeux et présentait

✉ Address for correspondence: Kalina Z. TRIFONOVA
Department of Ophthalmology, Medical Faculty, Trakia University
Address: 2 Gen Stoletov, Stara Zagora, Bulgaria
Email: kalina.trifonova@trakia-uni.bg

were more common in adolescents playing video games more than six hours a week.

Conclusions. The risk of developing digital eye strain in adolescents is very serious due to the wide use of smartphones in this age group.

Keywords: eye strain, questionnaire, children, smartphone, video game

List of abbreviations:
CVS – computer vision syndrome
DES – digital eye strain
CVS-Q – computer vision syndrome questionnaire

une corrélation positive avec la fréquence et la gravité des brûlures, de la fatigue oculaire, de la vision floue, de la vision double, de la photophobie, des paupières lourdes, des douleurs oculaires et des difficultés de concentration. Les femmes présentaient plus de symptômes de fatigue oculaire numérique que les hommes. De légers maux de tête étaient plus fréquents chez les adolescents jouant à des jeux vidéo plus de six heures par semaine.

Conclusions. Le risque de développer une fatigue oculaire numérique chez les adolescents est très élevé en raison de l'utilisation généralisée des smartphones dans cette tranche d'âge.

Mots-clés: fatigue oculaire, questionnaire, enfants, smartphone, jeu vidéo

Introduction

Computer vision syndrome (CVS) is the combination of eye and vision problems associated with the use of computers. The widespread use of different digital screens and devices like smartphones, laptops, tablets, personal computers, video games etc. has led to the emergence of a new term "digital eye strain" (DES) as a new clinical syndrome that affects any person who spends a large period of time fixed on multiple screens, for work or leisure[1]. The terms are still being used interchangeably in scientific literature.

Studies show that young people and adolescents are the most frequent users of these devices[2]. Their prolonged use not only causes stress to the visual system, but also musculoskeletal strain[3] and circadian disruption[4]. Symptoms associated with CVS can be classified as visual, ocular, and extraocular[5]. Visual symptoms include blurred vision, visual fatigue or discomfort, and diplopia. Ocular symptoms include dry eye, redness, eye strain and irritation. Extraocular symptoms include headache and shoulder, neck, and back pain. Furthermore, the most frequently reported symptoms fall into two groups[6]: symptoms related to accommodation – headache, eye pain and blurred vision for close objects, and symptoms related to dryness – foreign body sensation, tearing, burning, itching and redness of the eyes.

In ophthalmology practice, CVS is primarily diagnosed by surveying patients using a set of symptom-focused questions. Segui et al[7] have developed and validated a CVS questionnaire (CVS-Q), in which respondents rate the frequency and intensity of 16 symptoms associated with computer-induced eye strain. This questionnaire has subsequently been widely used in clinical trials to identify CVS.

The objective of the study was to analyze the effect of using different digital devices on the visual system of adolescent school children.

Materials and methods

A cross-sectional study was performed between April 2022 and April 2023. Questionnaires were handed out personally in two outpatient ophthalmology clinics in Stara Zagora and Kazanlak, Bulgaria. Only adolescent school children aged between 13 and 18 years were included in the survey. Written informed consent of their parents was taken beforehand. The questionnaires were filled in anonymously and no personal data was used in this report.

The questionnaire was divided into three parts: demographic information, time spent on different digital devices, complaints related to digital eye strain.

We adapted the validated CVS-Q using a 4-point Likert scale for rating symptom's frequency (0 = never, 1 = sometimes, 2 = often 3 = all the time) and severity (0 = none, 1 = mild, 2= moderate, 3 = severe).

Out of a hundred handed out questionnaires, 82 were fit for analysis. SPSS 19 was used for statistical analysis. Threshold for statistical significance was set at $p<0.05$. Descriptive statistics, crosstabulations and Pearson Chi-square test were used to test the relationship between variables. Phi and Cramer's V were calculated to measure the effect of the associations. Spearman's correlation was also calculated for some of the Likert scale variables.

Results

All students who visited the outpatient clinics during the one-year period were included in the study. The majority (43%) were aged between 13 and

Table 1. Demographic characteristics of the participants in the survey

Years	*Frequency*	*Percentage*
13-14	36	43.9
15-16	27	32.9
17-18	19	23.2
Gender	*Frequency*	*Percentage*
Male	32	39.0
Female	50	61.0
Location	*Frequency*	*Percentage*
Big town	6	7.3
Middle town	46	56.1
Small town	10	12.2
Village	20	24.4
Total	82	100.0

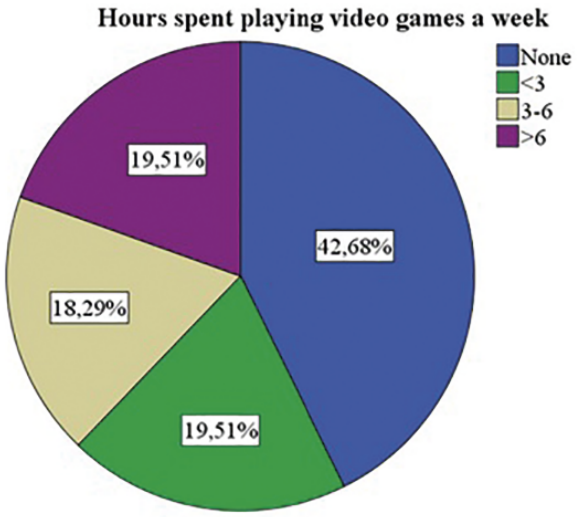


Figure 1. Hours spent playing video games a week

Table 2. Hours spent a day by adolescent school children using different digital devices

	Frequency (Percentage)			
	Personal Computer	*Laptop*	*Tablet*	*Smartphone*
Don't use	45 (54.9%)	44 (53.7%)	76 (92.7%)	3 (3.7%)
<1 h a day	9 (11%)	14 (17.1%)	2 (2.4%)	2 (2.4%)
1-2 h	15(18.3%)	9 (11%)	2 (2.4%)	15 (18.3%)
>2 h	13(15.9%)	15 (18.3%)	2 (2.4%)	62 (75.6%)

Table 3. Frequency of symptoms related to digital eye strain

	Symptom/ Frequency	*Never*	*Sometimes*	*Often*	*All the time*
1	Redness	41(50%)	34(41.5%)	6 (7.3%)	1(1.2%)
2	Dryness	45(54.9%)	27(32.9%)	10(12.2%)	-
3	Stinging	37(45.1%)	34(41.5%)	11(13.4%)	-
4	Eye Strain	34(41.5%)	34(41.5%)	11(13.4%)	3(3.7%)
5	Blurred vision	34(41.5%)	31(37.8%)	13(15.9%)	4(4.9%)
6	Often blinking	50(61%)	22(26.8%)	10(12.2%)	-
7	Eye pain	50(61%)	27(32.9%)	5(6.1%)	-
8	Headache	28(34.1%)	40(48.8%)	14(17.1%)	-
9	Double vision	64(78%)	15(18.3%)	3(3.7%)	-
10	Difficulty focusing	52(63.4%)	20(24.4%)	9(11%)	1(1.25%)
11	Heavy eyelids	61(74.4%)	17(20.7%)	4(4.9%)	-
12	Photophobia	36(43.9)	35(42.7%)	8(9.8%)	3(3.7%)
13	Itching	35(42.7%)	36(43.9%)	11(13.4%)	-
14	Burning	37(45.1%)	34(41.5%)	11(13.4%)	
15	Foreign body sensation	62(75.6%)	15(18.3%)	5(6.1%)	-
16	Tearing	44(53.7%)	26(31.7%)	9(11%)	3(3.7%)

14 years (Table 1) and more than half of them were female (61%). Most of the participants (56%) came from a middle size town, which we described as 30,000-100,000 population.

The results showed that only 3.7% of the students didn't use a smartphone and 75.6% of them (Table 2) spent more than two hours a day using one. They also showed that 57.4% (Fig. 1) of adolesecents played video games and 20% played for more than 6 hours a week.

The final report showed that 72% had at least two or more symptoms of DES. The most commonly

Table 4. Severity of symptoms related to digital eye strain

	Symptoms/ Frequency	*Mild*	*Moderate*	*Severe*
1	**Redness**	78%	19.51%	2.44%
2	**Dryness**	66%	27.7%	5.56%
3	**Stinging**	71%	26.67%	2.22%
4	**Eye Strain**	58.3%	35.4%	6.2%
5	**Blurred vision**	52%	39,5%	8,3%
6	**Often blinking**	59.38%	34.27%	6.25%
7	**Eye pain**	68.75%	28.13%	3.12%
8	**Headache**	61.11%	33%	5.56%
9	**Double vision**	66.7%	33.33%	-
10	**Difficulty focusing**	52%	39.5%	8.3%
11	**Heavy eyelids**	71.4%	23.8%	4.76%
12	**Photophobia**	62%	33.3%	4.4%
13	**Itching**	68.09%	29.79%	2.13%
14	**Burning**	71.1%	26.6%	2.2%
15	**Foreign body sensation**	75%	25%	-
16	**Tearing**	55.26%	34.2%	10.5%

Table 5. Positive correlation between hours spent using smartphone and digital eye strain symptoms

Spearman's rho		*Hours spent using smartphone*
Frequency of eye burning	Correlation Coefficient	0.290
	Sig. (2-tailed)	0.008
Severity of eye burning	Correlation Coefficient	0.268
	Sig. (2-tailed)	0.015
Frequency of blurred vision	Correlation Coefficient	0.235
	Sig. (2-tailed)	0.033
Severity of blurred vision	Correlation Coefficient	0.265
	Sig. (2-tailed)	0.016
Frequency of double vision	Correlation Coefficient	0.298
	Sig. (2-tailed)	0.007
Severity of double vision	Correlation Coefficient	0.297
	Sig. (2-tailed)	0.007
Frequency of photophobia	Correlation Coefficient	0.300
	Sig. (2-tailed)	0.006
Severity of photophobia	Correlation Coefficient	0.279
	Sig. (2-tailed)	0.011
Frequency of heavy eyelids	Correlation Coefficient	0.271
	Sig. (2-tailed)	0.014
Severity of heavy eyelids	Correlation Coefficient	0.272
	Sig. (2-tailed)	0.013
Frequency of difficulty focusing	Correlation Coefficient	0.371
	Sig. (2-tailed)	0.001
Severity of difficulty focusing	Correlation Coefficient	0.409
	Sig. (2-tailed)	0.000
Frequency of eye pain	Correlation Coefficient	0.273
	Sig. (2-tailed)	0.013
Severity of eye pain	Correlation Coefficient	0.260
	Sig. (2-tailed)	0.018

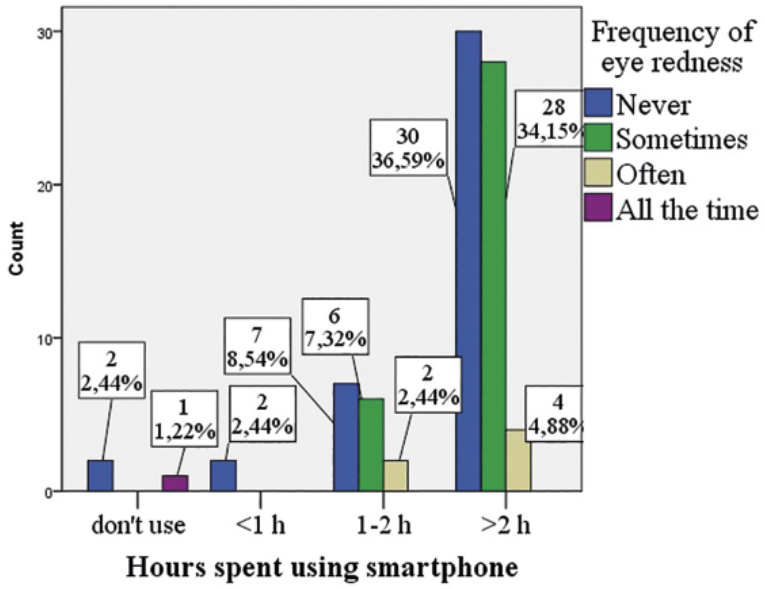


Figure 2. Association between hours spent using a smartphone and eye redness

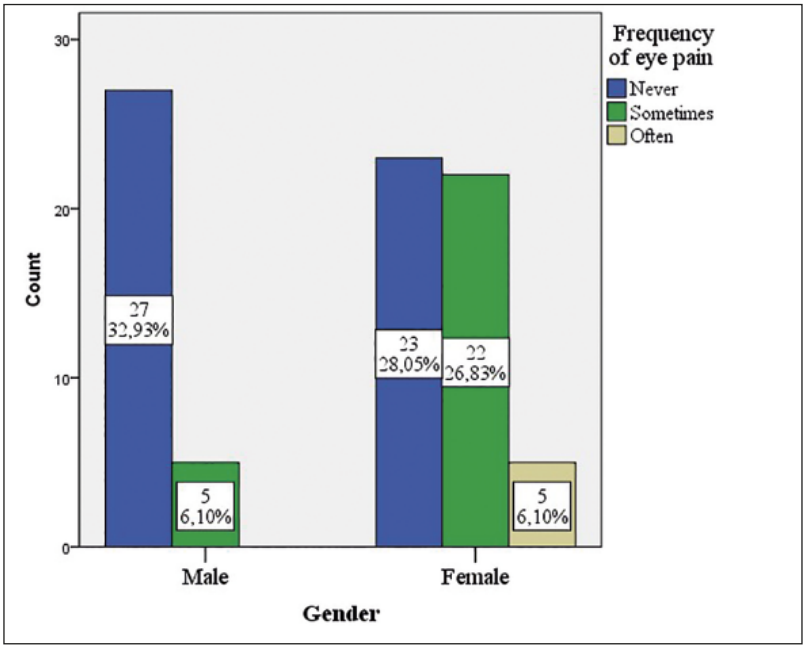


Figure 3. Association between frequency of eye pain and female gender

reported symptoms were headache (65.9%), eye strain (54.9%) and blurred vision (53.7%), followed by photophobia and stinging (Table 3). Blurred vision (Table 4) was the most severe complaint, with 47.8% rating it as moderate or severe. The least severe complaint was stinging, with 71% rating it as mild. The rarest reported complaints were double vision (22%), heavy eyelids (21%) and foreign body sensation (24.4%).

Time spent using a smartphone had strong association with frequency of eye redness (Fig. 2, Pearson Chi-square 31.022; p=0.000, Phi=0.615; Cramer's V=0.355). This symptom was reported by 51.61% of those who used a smartphone more than two hours a day. It also showed a weak, but positive correlation (Spearman's correlation coefficient, Table 5) with the frequency and severity of burning, eye strain, blurred vision, double vision, photophobia, heavy eyelids, eye pain and moderate correlation with difficulty focusing.

The results showed that female gender was associated with more common digital eye syndrome

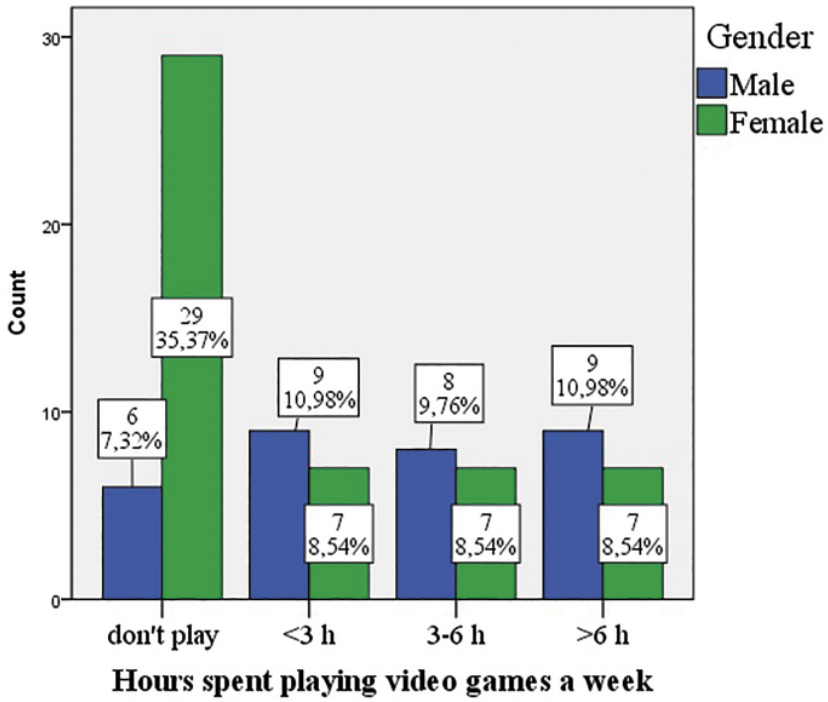


Figure 4. Association between male gender and hours spent playing video games a week

symptoms. It had strong association with the frequency (Fig. 3) and severity of eye pain ($p<0.0$; Phi and Cramer's $V>0.3$), frequency of difficulty focusing, photophobia and eye strain ($p<0.05$; Phi and Cramer's $V>0.3$) and moderate association with heavy eyelids ($p<0.05$; Phi and Cramer's $V=0.286$).

Playing video games had strong association with male gender (Fig. 4, $p<0.01$; Phi and Cramer's $V>0.3$). It was also strongly associated with frequency of eye strain and severity of headaches ($p<0.01$; Phi and Cramer's $V>0,3$). Mild headaches were more common in adolescents playing video games more than six hours a week ($p<0.01$; Phi and Cramer's $V>0.3$). The number of hours spent using video games showed a weak, but positive correlation with the frequency of eye redness (Spearman's rho correlation coefficient= 0.226, $p<0.05$).

Discussion

A significant proportion of the surveys on DES symptoms in children have been focusing on online education and its increased demands on the visual system. Headache[3,8,9] was the leading complaint of school age children, which corresponded with our results (Table 3). Demirayak et al. showed that using a display device for more than 3 hours a day was a significant risk factor for headaches. Similarly, blurred vision and eye strain were also frequently reported complaints[10].

Our results showed that female gender was an independent risk factor for many complaints related to DES, which was similar to the results of other authors[11-13]. For example, Ranasinghe et al[13] found a significantly greater prevalence of CVS (69.5%) in female compared to male participants (65.4%).

Several recent reports showed a greater prevalence of mobile devices usage among adolescents compared to other electronic devices[14,15]. This was in accordance with our results (Table 2), which showed that 96.3% of adolescents used a smartphone compared to only 45.1% who used a personal computer, 46.3% who used a laptop and only 7.3 % a tablet. This could be due to the ease of purchase, portability, easy access to the internet and a lot of other features such as social networking, video games and shows[16].

The results of Roberts et al. showed that women were more likely to increase excessive cell phone use than men. Men were exposed to less social stress and were less likely to use mobile phones for social purposes[17]. However, our study did not show statistically significant differences in smartphone use by gender.

A smartphone screen, due to its smaller size compared to a personal computer, is placed much closer to the eyes. This leads to a far greater visual strain on accommodation and convergence[18]. Similarly, our results a showed positive correlation of the duration of smartphone use and DES symptoms related to accommodation – double vision, blurred vision, difficulty focusing

and eye pain (Table 5). Cho et al. compared visual complaints and tear film condition after using a smartphone and after using a computer display[19]. Greater tear film instability and an increased oxidative stress index were found in tears and on the ocular surface after smartphone use. Our survey confirmed the connection between the duration of smartphone use and dry eye complaints. First, we found association with increased eye redness and second positive correlation (Table 5) with symptoms of burning and photophobia.

The research of Leonhardt and Overa showed that boys from the age of 14 years use video games up to 5 times more than girls[20]. Our study also showed a greater prevalence of male students playing video games: 83% vs 40% of females (Fig. 4). Problematic video game behavior was also more common in male students, 28% of them played more than six hours a week vs 14% of females. The studies on visual complaints strictly related to playing video games are very limited. Rechichi et al. are one of the few teams researching this problem. They showed that symptoms of asthenopia, especially headache, eyelid tics, transient diplopia and dizziness, lack of fine stereo vision, and a higher incidence of refractive errors, were statistically more common, especially for the dominant eye, in children playing video games more than three hours a day[21]. Our results also showed that playing video games was strongly associated with eye strain and headaches, especially in students playing for more than 6 hours a week.

One of our future aims as a team is to raise the awareness of the risks of prolonged use of digital devices especially in adolescents which are prone to developing addiction behavior towards screens. Since the modern era excludes the possibility of secession of their use at least, safety use guidelines need to be promoted to parents and teachers. The American Academy of Pediatrics recommends limitation of screen time for adolescents to up two hours a day[22] and cessation of screen use 60 minutes before bedtime. Outdoors physical activities are also recommended[23].

Our study had a few limitations: 1) selection bias due to the participation of patients visiting an outpatient ophthalmic clinic which increased the probability of ocular complaints; 2) small sample size; 3) the use of a symptom-based questionnaire which is subjective and may lead to recall bias.

Conclusions

The risk of developing DES in adolescents is very serious because of the wide use of smartphones in this age group. Regular eye examinations should be encouraged to ensure the use of optical correction and to meet the specific visual requirements.

Author Contributions:

Conceptualization: T.R.Y, K.Z.T, K.S.S.; methodology: T.R.Y, K.Z.T, K.S.S.; software: T.R.Y, K.Z.T, K.S.S; investigation: T.R.Y, K.Z.T, K.S.S.; writing original draft preparation: T.R.Y, K.Z.T, K.S.S; writing review and editing: T.R.Y, K.Z.T, K.S.S.; visualization: K.Z.T. and T.R.Y., supervision: K.S.S, K.Z.T. final approval of the version to be published: T.R.Y, K.Z.T, K.S.S. All the authors have read and agreed with the final version of the article.

All the authors have read and agreed with the final version of the article.

Compliance with Ethics Requirements:

„The authors declare no conflict of interest regarding this article".

"The authors declare that all the procedures of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all the patients included in the study"

"This study was approved by the Ethics Committee of the Medical Faculty of Trakia University, Stara Zagora, Bulgaria (approval number 19 from 2022) and the parents of all participants have signed a written informed consent.

"There was no funding for this study"

Acknowledgements:

None.

References

1. Mylona I, Deres E, Dere G, et al. The impact of internet and videogaming addiction on adolescent vision: a review of the literature. *Frontiers in Public Health* 2020; 8: 63
2. Uchino M, Yokoi N, Uchino Y. Prevalence of dry eye disease and its risk factors in visual display terminal users: The Osaka study. *American Journal of Ophthalmology* 2013;156:759–66
3. Demirayak B, Yılmaz B, Toprak M, et al. Digital eye strain and its associated factors in children during the COVID-19 pandemic. *Indian Journal of Ophthalmology* 2022; 70(3):988-992
4. Mohan A, Sen P, Peeush P, et al. Impact of online classes and home confinement on myopia progression in children during COVID-19 pandemic: Digital eye strain among kids (DESK) study 4. *Indian Journal of Ophthalmology* 2022;70(1):241-245
5. Association AO. Guide to the clinical aspects of computer vision syndrome. St. Louis, MO: American Optometric Association, 1995
6. Kelkar J, Kelkar A, Singhvi P. Commentary: Not just COVID-19 pandemic, it is a pandemic of digital eye strain among children. *Indian Journal of Ophthalmology* 2022; 70(3):993.
7. Seguí Mdel M, Cabrero-García J, Crespo A, et al. A reliable and valid questionnaire was developed to measure computer vision syndrome at the workplace. *Journal of Clinical Epidemiology* 2015; 68(6):662-73.

8. Mohan A, Sen P, Shah C, et al. Prevalence and risk factor assessment of digital eye strain among children using online E-learning during the COVID-19 pandemic: Digital eye strain among kids. *Indian Journal of Ophthalmology* 2021; 69:140–4.
9. Seresirikachorn K, Thiamthat W, Sriyuttagrai W, et al, Effects of digital devices and online learning on computer vision syndrome in students during the COVID-19 era: an online questionnaire study. *British Medical Journal of Paediatrics Open* 2022;6:e001429.
10. Ekemiri K, Ezinne N, Kamalodeen K, et al. Online e-learning during the COVID-19 lockdown in Trinidad and Tobago: prevalence and associated factors with ocular complaints among schoolchildren aged 11-19 years. *Peer J* 2022;10:e13334.
11. Zainuddin H, Isa M. Effect of human and technology interaction: computer vision syndrome among administrative staff in a public university. *International Journal of Business, Humanities and Technology* 2014; 4(3):38-44.
12. Abudawood G, Ashi H, Almarzouki N. Computer vision syndrome among undergraduate medical students in King Abdulaziz University, Jeddah, Saudi Arabia. *Journal of Ophthalmology* 2020, 4:1-7.
13. Ranasinghe P, Wathurapatha W, Perera Y, et al. Computer vision syndrome among computer office workers in a developing country: an evaluation of prevalence and risk factors. *BMC Research Notes* 2016;9:150.
14. Ofcom. Children and parents: Media use and attitudes report. 2017
15. Lauricella A, Cingel D, Blackwell C, et al. The mobile generation: youth and adolescent ownership and use of new media. *Communication Research Reports* 2014;31(4):357–364.
16. Lauricella A, Cingel D, Beaudoin-Ryan L, et al. The common sense census: plugged-in parents of tweens and teens. San Francisco CA: Common sense Media; 2016.
17. Roberts J, Yaya L, Manolis C. The invisible addiction: Cell-phone activities and addiction among male and female college students. *Journal of Behavioral Addictions* 2014; 3: 254-265.
18. Barker F. Effect of smartphones on vision and health of service members Military Health System, Communications Office, 2016.
19. Choi J, Li Y, Kim S, et al. The influences of smartphone use on the status of the tear film and ocular surface. *PLoS One.* 2018; 13(10):e0206541.
20. Leonhardt M, Overå S. Are there differences in video gaming and use of social media among boys and girls? A mixed methods approach. *International Journal of Environmental Research and Public Health.* 2021;18(11):6085.
21. Rechichi C, De Mojà G, Aragona P. Video game vision syndrome: a new clinical picture in children? *Journal of Pediatric Ophthalmology & Strabismus* 2017; 54(6):346-355.
22. Brody J. Screen addiction is taking a toll on children. *The New York Times*, 2015.
23. Xiong S, Sankaridurg P, Naduvilath T, et al. Time spent in outdoor activities in relation to myopia prevention and control: A meta-analysis and systematic review. *Acta Ophthalmologica* 2017; 95:551–66.