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RESEARCH ARTICLE

As a Featured "Cause of Dry Eye Syndrome" Digital Screens

Cüneyt Karaarslan, Arzu Coskun *

Vocational School of Health Services Department, Toros University, Mersin, Turkiye

ABSTRACT

As digital screens have become more indispensable in our lives, the health problems they induce have become more frequent. Dry eye syndrome may be the most common and preventable of these health issues. In this study, we investigated the adversity of digital screens on tear function. This study evaluated the possible negative and potentially harmful effects of digital screens on the lacrimal system and tear functions with the voluntary participation of 221 patients who applied to a private eye hospital in March and April 2024. While the ocular surface conditions of the participating volunteers were evaluated with Ocular Surface Disease Index (OSDI) scores, lacrimal activity functions were measured with the Schirmer test. The cases were 25-50 years old. The Ocular Surface Disease Index (OSDI) evaluated the severity of dryness in the eyes. We found a reciprocal and statistically significant difference between dry eye symptoms and OSDI scores. Smartphone usage for more than 5 years, especially with higher screen brightnesses, has been attributed to a higher risky behavior for dry eye syndrome.

Keywords: Dry eye syndrome, Digital Screens, Electromagnetic Radiation, Schirmer's test, OSDI score

* arzu.coskun@toros.edu.tr

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1. INTRODUCTION

The electromagnetic field is an environmental phenomenon that is created by particles carrying electrical potential and exerting force on the other surrounding particles. Electrical electronic devices create electromagnetic fields that can cause significant environmental impacts (1). Electrical devices and telecommunication devices such as radars, mobile phones, refrigerators, hair dryers, electric shavers, MRI equipment, radiological imaging devices, diathermy units, base stations, radios, and computers have an electromagnetic field that emits electromagnetic waves. Even just a small amount of continuous long-standing or intense sudden electromagnetic radiation can cause some serious health issues such as weakness in the immune defense system. A group of toxic substances may increase in the blood circulation and then headache, burning sensation on the skin, high blood pressure, dizziness, weight loss, and heart rhythm problems may occur. According to the National Institute of Environmental Protection and Health Science electromagnetic emission from mobile phones can cause some other neuromuscular disorders such as Alzheimer's, Parkinson's disease, and even multiple sclerosis (2). Today, the time we spend in front of digital screens is an indispensable part of our lives. Printed materials such as newspapers, magazines, or books are increasingly being replaced by digital copies. The characters in the printed materials can be seen more clearly than the digital ones. The reflections on glowing background brightness with diminished contrast and indistinct lines make it difficult to focus on digital screens. The enforced focus on digital media needs more attention and concentration. Focusing more causes blinking less and keeping the eye open for longer periods. Consequently, dry eyes become inevitable (3, 4).

It has long been known that the use of digital screens can cause some eye health problems such as dry eye and blurry vision (5). According to the American Optometric Association, this clinical condition is called Computer Eye Syndrome (CES), Digital Eye Strain (DES), or Digital Eye Fatigue (6). All of these conditions mention the same clinical condition that is associated with an increased use of digital screens such as smartphones, tablets, computers, LED screen TVs, tablets, game consoles, and e-books. The use of digital screens is becoming more and more popular globally among all age groups. Approximately there are 4.3 billion internet (57%), 3.5 billion social media (45%), and 5.1 billion (67%) mobile phone users in the world and about one million new users are being added to this list each day (3). To see better to have more background brightness in digital platforms is a common mistake. The prolonged use of digital devices in higher brightnesses may have some ocular problems such

as squeezing the eyelid, decreasing blinking, and excessive evaporation of tears leading to Dry Eye Syndrome (7,8).
Digital screens can cause dry eye, either through diminished secretion or excessive evaporation of tear film. Electromagnetic waves can reduce tear secretion through affected corneal sensory nervous system and meibomian gland dysfunction (9). Decreased lipid secretion affects tear stability and over-attention to digital devices may cause additional evanescences in tear film layers. Studies indicate that users experience reduced blink rates, leading to tear film instability and ocular discomfort. Prolonged screen use reduces blink rates by approximately 66%, leading to incomplete blinks and insufficient tear film replenishment, which exacerbates ocular dryness and discomfort (10,11). Symptoms of dry eye due to digital screen use include Dry, irritated eyes, Redness and itchiness, Gritty sensation, Mucous secretions, Episodic blurry vision, Eye strain and fatigue, Increased sensitivity to light, and Headaches (12).
The present study aimed to determine the relationship between dry eye syndrome and screen use in patients.

2. MATERIALS AND METHODS

All of the participants in the study were evaluated individually by anamnesis questionnaire, OSDI questionnaire, digital screen usage awareness level questionnaire, and Schirmer ‘s test.

Schirmer 's test

Schirmer 's test is conducted by a special strip placed on the temporal bulbar conjunctival sac. If the wetness of the strip is less than 5 mm, it is considered dry eye; if it is more than 10 mm, it is considered normal. The purpose of the Schirmer test is to assess tear production and diagnose dry eye disease. The following is the application of the Schirmer test:
1. Preparation: The patient should be in a quiet, draft-free environment, contact lenses should be removed, and any artificial tears or medications used by the patient should have been discontinued at least 2 hours prior.
2. Inserting the Paper Strip: A strip of Schirmer's filter paper (5 × 35 mm) is folded through a notch. For Schirmer's Test I (without anesthesia), the folded end is placed in the outer third of the lower eyelid. A local anesthetist is used before the test. Two separate measurements are taken before and after the anesthetist.
3. Duration: Once the strip is inserted into the eye socket, the patient should keep the eyes closed for 5 minutes.
4. Measurement: After 5 minutes the strip is removed, and the length of the moistened area is measured.
The results are interpreted according to the amount of moisture: >10 mm (without anesthesia) and >5 mm (with anesthesia), while <10 mm indicates dry eye disease
The Schirmer test is performed with a special paper strip placed in the center of the temporal bulbar conjunctival sac and the wetness of the strip is measured with a ruler. If the wetness of the paper strip is less than 5 mm, it can be considered dry eye, but if it is over 10 mm, it can be said to be normal [13].
The SPSS 27 (IBM) statistical analysis was used to evaluate the results of the study.
The "Mann-Whitney U" test, "Kruskal-Wallis H" test (χ2-table value),"Bonferroni" correction, and "Spearman" correlation tests were applied also to their relevant parameters.

Table 1. Descriptive data

Variable (N=221)	n	%
Age group		
<25	47	21,3
25-34	66	29,9
35-44	43	19,4
≥45	65	29,4
Gender		
Woman	122	55,2
Man	99	44,8
Chronic systemic diseases		
Yes	67	30,3
No	154	69,7
Smoking		
Yes	116	52,5
No	105	47,5

Wearing contact lenses		
Yes	46	20,8
No	175	79,2
Chronic eye disease		
Yes	70	31,7
No	151	68,3
Ocular trauma history		
Yes	45	20,4
No	176	79,6
Ocular surgery history		
Yes	89	40,3
No	132	59,7
Long-term topical eye medication		
Yes	60	27,1
No	161	72,9
Existing refractive error *		
Myopia	42	22,2
Hypermetropic	20	9,0
Myopia + Astigmatism	39	17,6
Hyperopia + Astigmatism	37	16,7
Astigmatism	26	11,8
No visual impairment	54	24,4
Wearing eyeglasses		
Yes	136	61,5
No	82	37,1
No regularly	3	1,4

The mean age was 37.65±15.62 and 66 of them (29.9%) were 25-34 years old. The number of female participants was 122 (55.2%).

It was found that the mean age of the participants was 37.65±15.62 (years), 66 (29.9%) were in the 25-34 age group, 122 (55.2%) were women, 154 (69.7%) did not have a chronic disease, 116 (52.5%) were smokers, 175 (79.2%) did not use contact lenses, 151 (68.3%) had no chronic eye disease, 176 (79.6%) had no history of ocular trauma, 132 (59.7%) had no ocular surgery, 161 (72.9%) had eye surgery. There was no long-term use of topical medication, 54 participants (24.4%) had no vision defects and 136 (61.5%) used glasses permanently.

Table 2. Duration of digital screen usage

Variable (N=221)	**Less than 1year**		**1-5 year**		**More than 5 years**		**No using**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Smartphone	5	2,3	12	5,4	204	92,3	-	-
LED TV	7	3,2	8	3,6	189	85,5	17	7,7
Computer	5	2,3	4	1,7	150	67,9	62	28,1
e-book	9	4,1	8	3,6	28	12,7	175	79,6
Tablet	3	1,4	22	10,0	53	24,0	143	64,7

Game console	3	1,4	10	4,5	33	14,9	175	79,2
Other digital display	3	1,4	6	2,6	57	25,8	155	70,2

The most prominent finding in this table is the usage rate and duration of the smartphones of 204 participants (92.3%).

Table 3. Daily time spent on digital screens

Variable (N=221)	**Less than 1 hour**		**1-5 hour**		**More than 5 hours**		**No using**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Smartphone	5	2,3	52	23,5	164	74,2	-	-
LED TV	45	20,4	72	32,6	89	40,2	15	6,8
Computer	8	3,6	25	11,3	128	57,9	60	27,1
e-book	28	12,7	9	4,1	4	1,8	180	81,4
Tablet	50	22,6	16	7,2	10	4,5	145	65,7
Game console	9	4,1	28	12,7	11	5,0	173	78,2
Other digital display	9	4,1	30	13,6	27	12,2	155	70,1

Especially using smartphones of the 164 (74.2%) participants with more than 5 hours in a day was a remarkable finding in this table.

Table 4. Adjusting the screen brightness in electronic devices

Variable (N=221)	**Low**		**Middle**		**High**		**No using**	
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Smartphone	8	3,6	85	38,5	128	58,0	-	-
LED TV	11	5,0	59	26,7	131	59,3	20	9,0
Computer	9	4,1	62	28,1	81	36,6	69	31,2
E-book	29	13,1	8	3,7	6	2,7	178	81,5
Tablet	25	11,3	37	16,7	14	6,3	145	65,6
Game console	4	1,8	27	12,2	18	8,2	172	77,8
Other digital display	4	1,8	27	12,2	35	15,8	155	70,2

It was determined in this table that the usage of the electronic screen with the high brightness might be the most common issue.

Table 5. The OSDI scores

Scale (N=221)	Average	S.S.	Median	Min.	Max.
OSDI score	21,40	19,59	16,7	0,0	97,9

Descriptive findings of individuals regarding their OSDI score are given in the table. It was determined that the average OSDI score of the individuals was 21.40±19.59.

Table 6. Reliability of the OSDI scores

Scale (N=221)	Number of items	Cronbach-α coefficient
OSDI score	12	0,920

The mean OSDI score for the right eye of the subjects was 18.38±7.08, and for the left eye was 19.46±7.35. The reliability coefficients of the OSDI scores of the participants are given in the table. It was found that the answers given to the OSDI questionnaire had a very high reliability level. It was also found that the mean amount of dryness in the right eye of the subjects was 18.38±7.08 and the average amount of dryness in the left eye was 19.46±7.35

Table 7. Comparison of the OSDI scores

Variable (N=221)		OSDI score		Statistical analysis* Possibility
	n		**Median [IQR]**	
Age				
<25 (1)	47	11,92±18,11	6,3 [14,6]	
25-34 (2)	66	17,77±16,83	12,5 [20,8]	$\chi 2$=52,677
35-44 (3)	43	19,19±19,61	14,6 [16,7]	**p<0,001**
≥45 (4)	65	33,40±17,75	29,2 [27,1]	**[1-2,3,4] [2,3-4]**
Gender				
Woman	122	22,51±21,15	16,7 [26,0]	Z=-0,480
Man	99	20,04±17,50	16,7 [22,9]	p=0,631
Chronic systemic disease				
Yes	67	30,85±18,19	27,1 [29,2]	Z=-5,600
No	154	17,29±18,79	12,5 [20,8]	**p<0,001**
Smoking				
Yes	116	22,38±18,65	18,8 [20,8]	Z=-1,727
No	105	19,91±20,81	12,5 [29,2]	p=0,084
Contact lens use				
Yes	46	16,81±17,08	12,5 [18,8]	Z=-1,806
No	175	22,39±20,14	17,7 [25,0]	p=0,071
Chronic eye disease				
Yes	70	33,81±18,12	30,2 [29,2]	Z=-7,280
No	151	15,25±17,53	11,5 [19,3]	**p<0,001**
ocular trauma history				
Yes	45	29,91±18,06	27,1 [30,2]	Z=-3,986
No	176	18,94±19,44	14,6 [22,9]	**p<0,001**

Ocular surgery history **There is** **None**	 89 132	 25,63±17,23 18,15±20,64	 22,9 [22,9] 12,5 [22,9]	 Z=-4,036 **p<0,001**
Long-term topical eye medication **Yes** **No**	 60 161	 33,41±18,82 16,63±18,03	 29,2 [30,7] 12,5 [20,3]	 Z=-6,146 **p<0,001**
Wearing eye glasses **Yes** **No**	 136 82	 26,58±19,13 13,03±17,68	 22,9 [24,5] 6,3 [19,3]	 Z=-6,065 **p<0,001**

The "Mann-Whitney U" test (Z-table value) was used to compare the measurement values of two independent groups in data that does not have a normal distribution, and the "Kruskall-Wallis H" test (χ2-table value) statistics were used to compare three or more independent groups.

Table 8. OSDI score comparison between the right and left eyes

Correlation * (N=221)		**OSDI score**
The right eye dryness	r p	-0,403 **<0,001**
The left eye dryness	r p	-0,404 **<0,001**

* "Spearman" correlation coefficient was used to examine the relationships of two quantitative variables that do not have a normal distribution.

A negative, weak, and statistically significant relationship was detected between the OSDI scores and the amount of dryness in the right and left eyes ($p<0.05$). As dryness increases in the right and left eyes, OSDI scores will decrease.

3. RESULTS AND DISCUSSION

Statistically significant differences were found in OSDI scores according to age ($\chi2 = 52.677$; $p<0.001$). As a result of Bonferroni Corrected Pairwise Comparisons performed to determine from which group the significant difference originated, the difference between those in the <25 age group and those in the 25-34, 35-44, and ≥45 age groups were highly significant. The OSDI scores of those in the 25-34, 35-44, and ≥45 age groups were significantly higher than those in the <25 age group. Similarly, significant differences were found between those in the 25-34 and 35-44 age groups and those in the ≥45 age group. The OSDI score of those aged ≥45 years was significantly higher than those aged 25-34 and 35-44.

Significant differences in OSDI scores according to chronic disease status (Z=-5.600; $p<0.001$) were found. The OSAS score of the participants with chronic disease was significantly higher than those without chronic disease.

Statistically significant differences in OSAS scores according to chronic eye disease status (Z=-7.280; $p<0.001$) were found. The OSDI scores of participants with chronic eye disease were found to be significantly higher than those without chronic eye disease.

Statistically significant differences were found in OSDI scores according to ocular trauma history (Z=-3.986; $p<0.001$). OSDI scores of those with ocular trauma history were significantly higher than those without ocular trauma history.

Statistically significant differences were found in OSDI scores according to ocular surgery status (Z=-4.036; $p<0.001$). OSDI scores of those who had ocular surgery were significantly higher than those who did not.

Statistically significant differences were found in OSDI scores according to long-term use of topical eye medication (Z=-6.146; $p<0.001$). It was found that OSDI scores of those who used topical medicines for the eye for a long time were significantly higher than those who did not use topical drugs for a long time.

Statistically significant differences were found in OSDI scores for permanent spectacle use (Z=-6.065; $p<0.001$). OSDI scores of permanent spectacle wearers were signif-

icantly higher than those of non-permanent spectacle wearers.

There was no statistically significant difference in OSDI scores regarding gender, smoking, or contact lens use ($p>0.05$). Nowadays, it is widely accepted that using digital screens nearby for a long time can lead to serious health problems.

In a previous study, performed by OSDI questionnaire, Schirmer test, and TBUT on 42 computer users 20-40 years old who had a history of using computers at least 6 hours a day, 39 cases had mild to severe ocular surface disorders. The OSDI scores were 45.2 ± 25.6, tBUT tests were 10.7 ± 5.9 sec, and Schirmer's tests were 12.1 ± 6.65 mm in those cases. The OSDI score had a negative correlation with, but not with, the Schirmer test (13).

In the study conducted by Wu et al.; It was reported that the Ocular Surface Disease Index (OSDI) score and corneal Fluorescein staining score were significantly higher in the group that spent more than four hours in front of the computer compared to the other group, and the LOS was dramatically shorter (14). In another study, in which the frequency of internet addiction and dry eye disease was evaluated on 2309 students, it was reported that the average OSDI score was 21.63 ± 17.86, and a significant weak relationship was found between the Young Internet Addiction Scale and OSDI results (15).

Author Contributions

Cüneyt KARAARSLAN: Conceptualization, Methodology, Software, Data curation, Writing- Original draft preparation. Arzu COŞKUN: Visualization, Investigation, Software, Validation, Writing- Reviewing and Editing,

Conflict of Interest

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4. CONCLUSION

Our study found that smartphones are the most common digital devices worldwide, and screen brightness and screen time are among the most essential factors behind ocular surface disorders related to their use.

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