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Dry eye in digital screens users

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Short title: Dry eye in digital screens users

Abstract

Purpose: This study was done to determine the relation between digital screens use and the prevalence of dry eye disease using Media works Dry eye diagnostic system (D130) & OSDI.

Patients and methods: The study enrolled 132 subjects who are digital screens users. The outcome measures were non-invasive break up time (NIBUT), tear meniscus height, lipid layer, eyelid edge, meibomian gland, ocular surface staining & eye redness analysis. Also assessment of blink rate, duration of digital screens use & accommodative spasm was done.

Results: Most of participants (90.9%) had eye discomfort (62.1%) of them use digital screens > 3 hours & use digital screens at bedtime. Blink rate was low in (69.7%) of participants, accommodative spasm was found in (34.8%) of them. The results were classified to three groups according NIBUT (Normal, warning to dry eye & dry eye), the bed time digital screen use, type of digital screen & amount of accommodative spasm were found to be statistically significant different between the NIBUT groups ($p= 0.004$, 0.025 & 0.019, respectively). Dry eye diagnostic system parameters, were more affected in dry eye group with statistically significant differences between three groups regarding tear meniscus height, lipid layer , meibomian gland loss, eye lid edge, eye redness & ocular surface staining ($p<0.001$, <0.001, <0.001, <0.001, 0.001 & <0.001, respectively).

Conclusion: digital screens use was associated with tear film instability. It was related to use of digital screens for longer duration. Assessment of DED by dry eye diagnostic system allows prediction of (DED).

Key words: dry eye disease, digital screens, duration of digital screens use, media works dry eye diagnostic system.

INTRODUCTION

In today's world there is an increasing use of digital screens in our lives. The term Computer Vision Syndrome is now being recognized as Digital Eye Strain (DES)[1]. The phenomenon is seen across all age groups. It is estimated to be present in more than 50 percent of users. Bedtime mobile phone usage among adults has become a common habit and it is commonly associated with sleep deprivation[2,3].

Digital Eye Strain (DES) causes various ocular and/or visual disturbances while using a digital device. Initially the symptoms are transient and are ignored, but once they become frequent and persistent, the professional help is sought. Most of the people with digital eye strain require minor life style modification for recovery[4,5]. Symptoms reported by computer users are classified into internal ocular symptoms (strain and ache it is now emerging as a global health issue. The condition presents as a discomfort in long use of these equipment[6].

Evaporative dry eye occurs due to abnormal blink rate when people keep their eyes open to stay focus on the display, reducing the blink rate down to 5–6 times/minute. This increases the duration of exposure and evaporation on the ocular surface and can lead to instability of the tear film, resulting in complaints of dry eye[7]. Meibomian gland dysfunction commonly causes aqueous tear deficiency[8,9].

Additionally, people with pathological internet use have emotional dysregulation, lack of confidence, and social support[10]. These alterations generate a state of psychological stress that through the release of inflammatory cytokines such as IL-1β, IL-6 and IL-8 generate the instability of the tear film, as well as the suppression of tear production, generating dry eye disease[11,12]. So this study was done to determine the relation between digital screens use and the prevalence of dry eye disease.

PATIENTS AND METHODS:

This was a descriptive analytic cross sectional observational study which included (132) subject from attendance to Mansoura ophthalmic center, Mansoura University, Egypt' 'between'' August 2022 to December 2023.

The study included digital screens users, from both genders, with age between 10 to 30 years & normal eye and adnexa on external examination. The exclusion criteria included allergic conjunctivitis, palpebral fissure abnormalities, history of any ocular disease or topical medication, use of contact lens or glasses, previous ocular surgery or trauma & any systemic diseases which may induce tear film abnormalities e.g. Auto immune disease &Diabetes mellitus.

The study was approved by the institutional research board (IRB) NO: MS:22.08.2087, Faculty of Medicine Mansoura university. Verbal consents were taken from the participants after explanation of the aims, methods, and anticipated benefits. Accordance the tens of dedication of Helsinki.

The data was collected by conducting a personal interview and using prepared questions & OSDI questionnaire. Questions consisted of general history including (Age, gender, Residence & Special habits as smoking), Past history of ocular & systemic disease, whether there is discomfort in the eyes, and duration of digital screens usage in a day (Duration of using a smartphone is the amount of time a subject spends over one day in units of hours, with a minimum period of 1 month (Objective Criteria: Normal: ≤3 h/day & high: >3 h/day).

Ocular Surface Disease Index questionnaire was assessed on a scale of 0 to 100, with higher scores representing greater disability. Measurement of blink rate for 1-min during smartphone use was done observationally in the interview, calculation process was performed three times, normal blink rate ranged from 10 to 15 times/ minute. *Objective criteria* (Low: ≤10 times/minute, Normal: >10–15 times/minute & High: ≥15 times/minute).

After that ophthalmic examination was done including uncorrected & best corrected visual acuity using standard Landolt chart then transformed to LOGMAR for statistical analysis. Manifest & cycloplegic refraction were done for assessment of accommodative spasm, followed by slit lamp bio microscopy for examination of ocular surface, lid margin, anterior segment, and tear film evaluation.

Tear film & ocular surface were evaluated using Media works Dry eye diagnostic system (D130). It is non-invasive test allowing precise and repeatable assessment of tear film more preferable to invasive techniques, avoids instillation of fluorescein and there is no contact between measuring instrument and the eye or eyelids. Examination started by data entry including, patient name, ID and date of birth. Then select 130 software system, finally start recording data. Seven tear film parameters were assessed.

The Non-invasive break up time (NIBUT) automatically acquires the first & average break up time. The examination scope was 8mm to bring much more comprehensive diagnosis outcome (Use Placido ring, magnification x10, and the patient were asked to blink once then keep eye opened & stop shooting after 20 sec).

Grading of NIBUT'' Grade 0 (Normal): first rupture Time: 10 s, average rupture time: 14 s, Grade I (Warning): first rupture time: 6-9 s, average rupture time: 7-13 s, and Grade II (Dry eye): first rupture time: 5 s, average rupture time: 7 s. figure (IA)

Media Works measures the tear meniscus height (TMH) automatically or manually, with normal value ≥0.2mm figure (IB).

Next lipid layer thickness were assessed using white ring projection system, magnification x10, and patient were asked to blink every 2 sec., the software stop shooting after 10 sec. Grading was done by comparing the result with the standard grading template. Grading'' Grade I: <15 (unit-nm), Grade II:

15 (unit-nm), Grade III: 30 (unit-nm) & Grade IV: 30-80 (unit-nm) figure (IC).

After that meibomian glands (MG) were assessed using built-in infrared lighting system which expands the image scope of glands, with adjustable depth of field making the glands more prominent and distinguishable against the background (dry eye module were removed, magnification x6, images were taken for upper &lower MG, which were analyzed automatically (Grade 0: No Meibomian Glands Loss, Grade I: Meibomian Glands Loss ＜ 1/3, grade II: Meibomian Glands Loss 1/3 to 2/3, &Grade III: Meibomian Glands Loss ＞2/3) figure (ID).

Next, eyelid margin were evaluated using the optical system of Media works (magnification x10, focus on eyelid & image were taken for upper &lower eyelid margin).Grading'' Grade I: Normal (bright, transparent), Grade II: Mild (gland cap crown - glandular prominent), Grade III: Moderate (glandular fat plug - disappearance of the marginal mucosa, hyperkeratosis), and Grade IV: Severe (uneven margins, disappearance of the meibomian glands - posterior margin blunt round, thickening, and new blood vessel) figure (IIE).

Afterword conjunctival & ciliary congestion were evaluated, with normal value ≤2 figure (IIF). Finally, early corneal & epithelial staining were done built in yellow filter & cobalt blue filter figure (IIG).

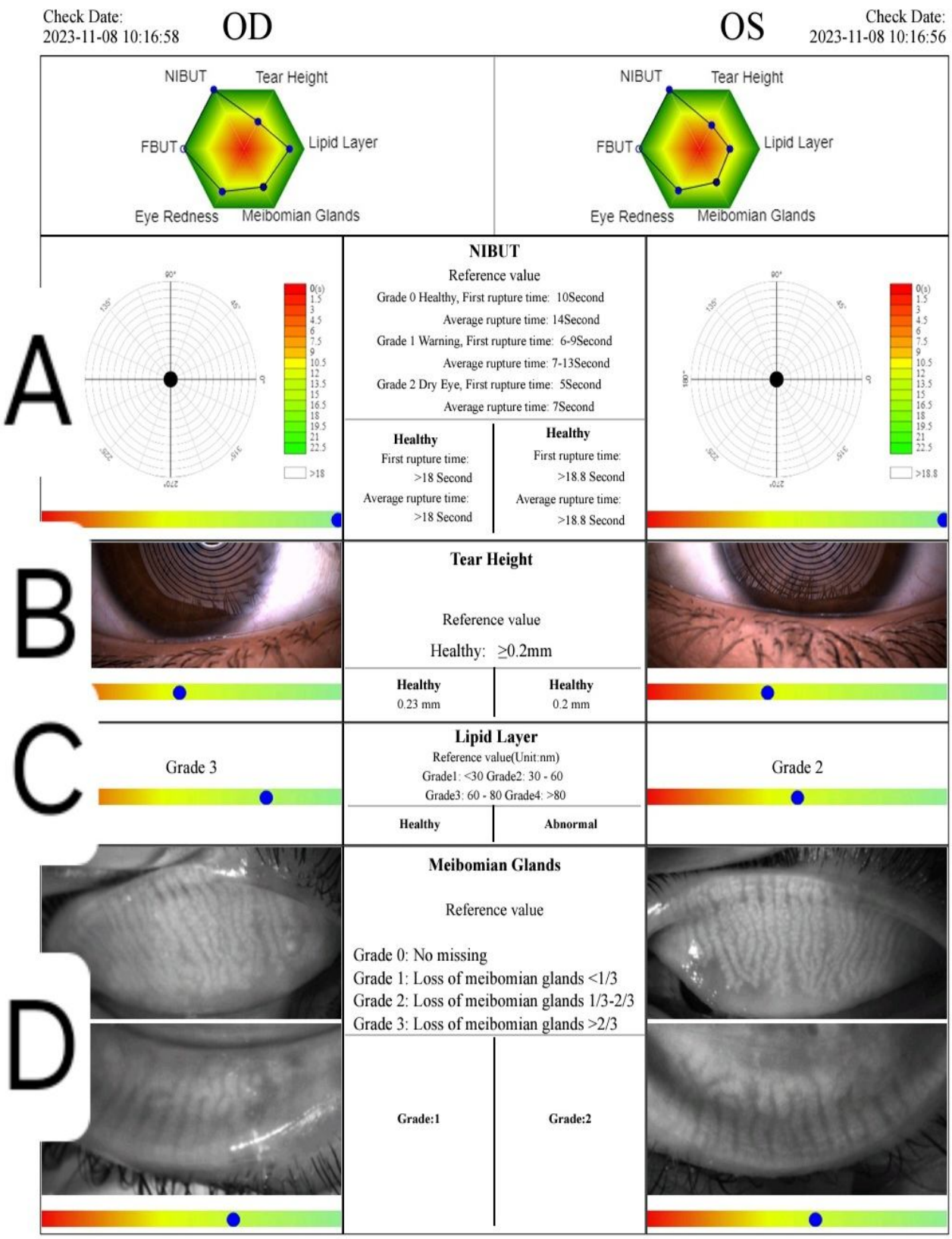

Figure (I) Dry eye comprehensive evaluation report (A: NIBUT, B: TMH, C: lipid layer thickness, D: MG, E: eyelid margin, F: Conjunctival & ciliary congestion, G: corneal & epithelial staining).

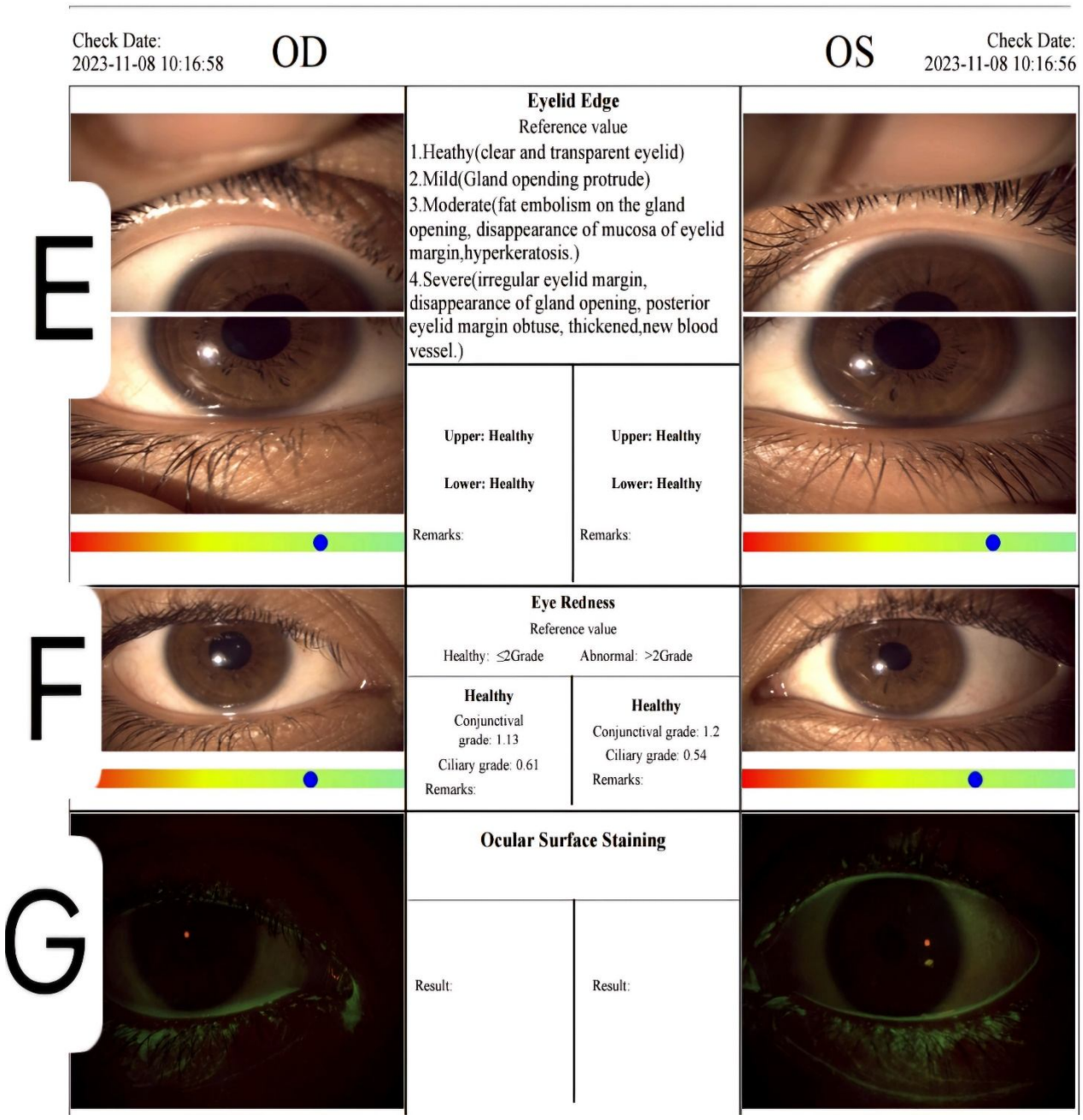

Figure (II) Dry eye comprehensive evaluation report (E: eyelid margin, F: Conjunctival & ciliary congestion, G: corneal & epithelial staining).

Statistical analysis:

Data were analyzed by the SPSS software version 24 for Windows. At first, normal distribution of data underwent testing using one-sample Kolmogorov-Smirnov test.

Qualitative data were expressed as frequencies and percentages. Continuous variables were expressed as means ± SDs (standard deviations) for normally distributed data and medians (minimum, maximum) for non-parametric data. The two paired groups were compared with paired t test. A result was considered significant if the $p \leq 0.05$.

RESULTS:

In this study, the median age of participants was 17 years, with 59.1% were female & 40.9% were males, about 62.1% of participants use digital screens > 3 hours & 62.1% use digital screens at bedtime. Most of participants was using cell phone. Low blink rate was found in more than half of participants, n=92,

69.7%. Accommodative spasm was found in 34.8% of participants, with median amount 2.5 diopters. The grading of OSDI questionnaire was found to be moderate in 50%, severe in 36.4% of participants & the median OSDI score was 51.25. Details of demographic, clinical & OSDI data are illustrated in table (1).

In our study NIBUT was found to be warning to DED in 43.9% & DE in 19.7%, TMH was abnormal in 42.4%, lipid layer thickness was abnormal in 37.9%, meibomian gland missing was grade I in 53% & grade II in 22.7%, eye lid edge was mildly affected in 56.1%, eye redness was found in 13.6%, positive ocular surface staining was found 1.6% of participants in the right eye, while in the left eye NIBUT was found to be warning to DED in 51.5% & DE in 6.1%, TMH was abnormal in 33.3%, lipid layer thickness was abnormal in 40.9%, meibomian gland missing was grade I in 68.1% & grade II in 12.1%, eye lid edge was mildly affected in 56.1%, eye redness was found in 10.6%, positive ocular surface staining was found 4.5% of participants. Details of tested parameters are illustrated in table (2), (3).

Table (1): details of demographic, clinical & OSDI data

	Mean	**±SD**
Age (years)	17	13-20
	N	**%**
Sex		
Male	54	40.9
Female	78	59.1
Eye discomfort	120	90.9
Duration of digital screen use		
≤ 3 hours	50	37.9
> 3 hours	82	62.1
Bedtime digital screen use	82	62.1
Blink rate		
Low	92	69.7
Normal	22	16.7
High	18	13.6
Accommodative spasm	46	34.8
OSDI Grade		
Normal	10	7.6
Mild	8	6.1
Moderate	66	50.0
Severe	48	36.4
	Median	**Range**
OSDI score	51.25	40 - 68.75

Table (2): Noninvasive tear break-up time (NIBUT).

NIBUT Grade	**Right eye**	**Grade 0 (normal)**	**48**	**36.4**
		Grade 1 (warning)	58	43.9
		Grade 2 (dry eye)	26	19.7
	Left eye	**Grade 0 (normal)**	56	42.4
		Grade 1 (warning)	68	51.5
		Grade 2 (dry eye)	8	6.1

Table (3): Dry eye diagnostic system parameters.

			N	%
Abnormal TMH	**Right eye**		56	42.4
	Left eye		44	33.3
Abnormal lipid layer thickness	**Right eye**		50	37.9
	Left eye		54	40.9
Meibomian gland loss	**Right eye**	**Grade 0 (no missing)**	32	24.2
		Grade 1 (<1/3 loss)	70	53.0
		Grade 2 (1/3 - 2/3 loss)	30	22.7
	Left eye	**Grade 0 (no missing)**	26	19.7
		Grade 1 (<1/3 loss)	90	68.2
		Grade 2 (1/3 - 2/3 loss)	16	12.1
Mildly affected eyelid edge	**Right eye**		74	56.1
	Left eye		74	56.1
Eye Redness	**Right eye**		18	13.6
	Left eye		14	10.6
Positive Ocular Surface Staining	**Right eye**		2	1.5
	Left eye		6	4.5

According to NIBUT the studied cases were classified into three groups (Normal, n=30, 22.7%, warning to dry eye n=70, 53.03 & dry eye n=32, 24.24%).

Regarding demographic characteristics & NIBUT, there were no statistically significant differences between three groups regarding gender or age (p=0.628, 0.138) respectively. In the terms of clinical data, only the bed time digital screen use was found to be statistically significant between the three groups, being more in DE group (p= 0.004).concerning OSDI grade & score they were high among dry eye group with statistically significant difference between the three groups (p= 0.012 & 0.007) respectively. Comparisons of demographic & clinical data among three groups are illustrated in table (4).

Table (4): Comparisons of demographic & clinical data among three groups.

Characteristic	NIBUT						Sig.
	Normal n=30		Warning n=70		Dry eye n=32		
	N	%	N	%	N	%	
Sex							0.628[1]
Female	16	35.3	44	62.9	18	56.3	
Male	14	46.7	26	37.1	14	43.8	
	Median	**Range**	**Median**	**Range**	**Median**	**Range**	**Sig.**
Age	18	15-20	16	13-22	15	13-18.5	0.138[2]
Eye discomfort	**26**	**86.7**	**66**	**94.3**	**28**	**87.5**	**0.288[1]**
Duration of digital screen use							0.164[2]
≤ 3 hours	8	26.7	26	37.1	16	50	
>3 hours	22	73.3	44	62.9	16	50	
Bed time digital screen use	12	40	44	62.9	26	81.3	**0.004[2*]**
Accommodative spasm	12	40	22	31.4	12	37.5	0.667[2]
Blink rate							
Low	24	80	46	65.7	22	68.8	0.546[1]
Normal	4	13.3	14	20	4	12.5	
High	2	6.7	10	14.3	6	18.8	

On comparing different dry eye diagnostic system parameters, it was found that, they were more affected in dry eye group with statistically significant differences between three groups regarding TMH , lipid layer thickness, meibomian gland loss, eye lid edge, and ocular surface staining. Comparison of dry eye diagnostic system parameters between three groups are illustrated in table (5).

Table (5): Comparisons of the diagnostic system parameters among NIBUT groups.

Characteristic	NIBUT group						Sig.
	Normal n=30		Warning n=70		Dry eye n=32		
	N	%	N	%	N	%	
Abnormal tear meniscus height	12	40	34	48.6	28	87.5	**<0.001[1]**
Lipid layer abnormality	6	20	30	42.9	32	100	**<0.001[1]**
Meibomian gland missing	16	53.3	68	97.1	32	100	**<0.001[2]**
Mildly affected eyelid edge	10	33.3	50	71.4	28	87.5	**<0.001[1]**
Ocular surface staining	0	0	0	0	8	25	**<0.001[2]**

Binary logistic regression was run to ascertain the effects of the occurrence of dry eye. Bedtime digital screen use, eyelid

edge, and tear meniscus height were found to exhibit dry eye. On univariable analysis, all were statistically significant predictors of dry eye, while on multivariable analysis, both bedtime digital screen use, and abnormal tear meniscus height were statistically significant independent predictors of dry eye. Participants with bedtime digital screen use, and abnormal tear meniscus height have (17.6, 33.3) times respectively higher odds to exhibit dry eye. Details of predictors of occurrence of dry eye are shown in table (6).

Table (6): Predictors of the likelihood of occurrence of dry eye.

Predictor	**Univariable**			**Multivariable**		
	Sig.	**COR**	**95% CI**	**Sig.**	**AOR**	**95% CI**
Bedtime digital screen use	**0.001***	6.5	2.059-20.520	**0.001***	17.551	3.153-97.689
Eyelid edge	**<0.001***	14	3.839-51.050	**<0.001***	33.339	5.688-195.417
Tear meniscus height	**<0.001***	10.5	2.928-37.557	-	-	-

DISCUSSION:

Dry eye is an ocular surface eye disease caused by many factors. One of these factors is electronic media usage[13]. Use of computers and digital screens decrease the number of eye blinks, leading to incomplete blinking, evaporation of tears, and subsequently to dry eye disease. The most common type of dry eye disease is an evaporative type, and the use of computers is especially important in this group[14]. So, this cross-sectional analytic study was conducted to determine the relation between use of digital screen and the incidence of dry eye.

In our study the median age of participants was 17 years, 59.1% of them were females & 40.9% were males, 90.9% had eye discomfort, 62.1% use digital screen > 3 hours & at bedtime. DED incidence was found to be higher in females.

Similarly, female sex was likely to be associated with an increased risk of dry eye disease[15]. However, another study revealed that there was no significant differences in gender distribution between the dry eye disease group and control group[16].

Studies revealed that, even minimal exposure to mobile devices may increase the risk of developing evaporative dry eyes, as one of the symptoms of CVS in young persons with normal tear production[17]. For instance, another study showed no association between reported dry eye symptoms and the amount of time spent using digital screens[18].

According NIBUT, the studied cases were classified into three groups, normal (n =30, 22.7%), warning to dry eye (n=70, 53%) & dry eye (n=32, 24.2%). Bed time digital screen use, type of digital screen, and amount of accommodative spasm were found to be statistically significant different between the NIBUT groups, (P=0.004, 0.025, 0.019) respectively.

Similarly there was no correlation between dry eye and screen time[19]. However Akkaya et al., found that TBUT was significantly lower in the group using computer compared to the control group. In addition, when the evening TBUT measurements were compared with the morning measurements, there was a significant decrease in the computer users group[20]. Also, students using mobile phones for more than 8 hours per day are more susceptible to dry eye disease[21].

In our study accommodative spasm was found in 34.8 % of participants. Similarly the use of computers was significantly associated with the prevalence of myopia and there was more myopic refractive error in children 5–16 years old[22].

However, several studies reported that the number of hours per day playing with electronic devices was not associated with myopia[23].

In the current study, the blink rate was low in most of participants, but there was no statistically significant difference between three groups. Similar to our results the use of a smartphone can lead to evaporation of the tear layer due to a

decrease in the number of blinks and imperfect blinks. Also there was a positive correlation between incomplete blinking and dry eye symptoms in computer users & a negative correlation between the number of blinks and the same symptoms[14]. However there was a significant correlation between the prolonged use of smartphone and abnormal blink rate[24].

In this study, there was statistically significant difference between NIBUT groups regarding OSDI grade and score, being higher in dry eye group. Similarly, it was reported that OSDI scores were significantly higher in the group using computers for a long time[25]. In disagreement with this study, there was no statistically significant difference between the study and control groups in terms of OSDI scores. They think that the lack of any difference between OSDI scores among the study participants due to the fact that they had not complaints of eye dryness, and all of them were healthy individuals[20].

In our study regarding the diagnostic system parameters, highly statistically significant differences were found between NIBUT groups regarding TMH, lipid layer thickness, MG missing, eyelid edge (p=0.001), and ocular surface staining. However, there was no statistically significant association between accommodative spasm and duration, lipid layer and duration of digital screens use, or between blink rate and lipid layer.

Similarly, Zahid et al. found that screen time has a significant effect on tear film stability & increasing screen time has a serious negative impact on eyes, inducing dryness[26].

However, another study reported that prolonged computer use does not lead to significant changes in dry eye tests, suggesting that screen time may not be a substantial contributing factor to the development of dry eye syndrome[20].

In the current study, bedtime digital screen use, eyelid edge, MG & lipid layer thickness were significant predictors of occurrence of dry eye warning. While the bedtime digital screen use, eyelid edge, and tear meniscus height were the predictors of occurrence of dry eye.

Similarly the results of Moon et al. revealed that the use of smartphones, the mean duration of smartphone use, and the mean duration of total video display terminal use were risk factors for dry eye disease[16].

Taken together, these studies common beliefs often suggest a strong association between prolonged screen exposure and ocular discomfort.

CONCLUSION:

Digital screens use has been associated with a number of DE symptoms and signs, most notably tear film instability. This instability may be caused by blink abnormalities, Meibomian gland and ocular surface exposure. Media works dry eye diagnostic system may help in prediction of dry eye disease to avoid its occurrence. Lifestyle modifications, blinking exercises, and workstation humidifiers helps in optimizing DED.

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Conflict of interest

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