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Toxicological Effects of Generated Radiations on the Eye among Computer Users

[1]Nadia I. Mohammad, [2]Omaima I. Abo-Elkheir, [1] Rehab A. Masoud, [3]Hosny H. Mohammed, [1]Neveen A. Ibrahim

[1]Forensic Medicine and Clinical Toxicology Department, [2]Community and Occupational Medicine Department ,[3]Ophthalmology Department, Faculty of Medicine - Al Azhar University, Cairo, Egypt

ABSTRACT

Background: Nowadays computers being used in every aspect of life in both developed and developing countries. These electronic devices generate a form of non-ionizing electromagnetic radiation which exerts negative influence on human health. Eyes are particularly vulnerable; thus computer vision syndrome or dry eye disease is the most frequent health problems among computer users. This study **aims to** assess toxic effects of computer generated radiation on eyes among a sample of Egyptian computer users. **Subjects and Methods:** this is a cross-sectional study conducted on 100 volunteers from both sexes who worked daily on a computer. All participants were subjected to a self-filling questionnaire including questions about personal information, work and workplace related information as well as, Ocular Surface Disease Index (OSDI) with 12 questions about symptoms of eye and vision problems. **Results:** this study revealed that more than three fourths (79.0%) of the studied computer workers suffered from symptoms of dry eye disease, 40.5% of them had severe eye affection, 26.6 % had moderate and 32.9 % had mild eye affection. Those with severe eye affection of participants with dry eye disease were using the computer for a mean duration of 10.3 ± 2.4 hour/day and 70.9 % of them not taking regular rest during computer work. Wearing visual aids showed a significant association with dry eye disease (P = 0.002).**Conclusion:** the majority of participants had symptoms of dry eye disease. The most vulnerable persons were those who wearing medical glasses or lenses and use the computer for around 10 h / day without regular rest. Occurrence of eye dryness was relevant to the presence of fan and air conditioner in the workplace. These results indicated the valuable role and the essential need for visual assessment of computer workers for early and proper diagnosis of dry eye disease in order to minimize its impact on their productivity and quality of life.

Keywords: Computer users, generated radiations, eye symptoms**,** ocular Surface Disease Index (OSDI**)**

INTRODUCTION:

With the rapid development of information technology, the reliance of people on technology is increasing; hence the dangers on human health are also increased day by day. The modern computers represent a sophisticated system composed of several electric and radio electronic devices.**(1)** Sources of Electromagnetic Field (EMF) include natural sources from the sun or artificial sources.**(2)** The level of electromagnetic radiation (both ionizing and non-ionizing) from artificial sources exceeds the level from natural sources by thousand folds.**(3)** Everyone is exposed to two types of non-ionizing electromagnetic field. The extremely low frequency (ELF) generated radiation from wire devices such as electronic appliances and electrical power lines. Plus the radiofrequency (RF) radiation from wireless devices such as cell phones, cordless phones, cellular antennas and broadcast transmission towers.(4) Employees who working for hours on computer or even sitting in a computer workplaces are directly exposed to the harmful effects of non-ionizing electromagnetic radiation.**(5)** The most frequently occurring health problems among computer users are Computer Vision Syndrome (CVS), pain of wrist and shoulder, low back pain, tension headaches and psychosocial stress.**(6)**

A number of epidemiological studies reported a relation between environmental Extremely Low Frequency Electromagnetic Field (ELF-EMF) and the onset of leukemia or Alzheimer's disease. **(7)**

The oscillating electrons that hit the bright surface of the computer screen emit an electromagnetic radiations (EMR) which continue for hours in the environment even after shutting down the computer and negatively affects the living cells.**(8)**

This besides the use of high voltage electronic lamps in monitors that generate an electron beam, visible light and a small amount of UV rays. Moreover, the monitor's electronic components and the electric circuit which controls the movement of electron beam create a range of radio waves. **(9)**

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Prolonged computer usage (more than four hours daily) creates several potential hazards on human health related to radioactive emissions from monitors (x-rays/ gamma rays, ultraviolet).[8]In addition to the glare reflection, electromagnetic field radiation from monitors and the chemical out gases from computer hardware materials. [10]

Surveys on computer workers revealed that vision-related problems are the most frequently occurring health problems among over 70% of computer workers.[11] Problems of eye and vision related to computer use has been termed the Computer Vision Syndrome (CVS) or Asthenopia which is a new problem that has been emerged in this century.[11,12] It denotes eye problems associated with heavy use of computers.[13]

The American Optometric Association and the Occupational Safety and Health Administration [OSHA] defines computer vision syndrome as " a complex of eye and vision problems related to activities which stress the near vision and occur during the use of the computer in the form of a repetitive strain disorder that appears to be growing rapidly".[14]

Different terms have been used to describe symptoms of CVS, such as visual discomfort, ocular disorder and visual difficulty.[15] Asthenopia is the most common eye complaint among people who perform prolonged reading or near vision tasks at the computer screen[16] and eye strain is the leading problem among computer users.[17]Eye strain is defined as blurred or double vision, eye irritation, headache, eye fatigue, color perception change, decrease visual efficiency, and more frequent visual errors . [18]

Visual acuity and color vision among computer users are decreased when compared to non-computer users [19] and a transient myopia was observed in 20% of computer users at the end of their work shift. [20]

A proper history taking and a detailed eye examination including visual acuity measurement, assessment of convergence, refraction and evaluation of dry eye are required for diagnosis of CVS. [21] With the unavailability of a uniform criteria for diagnosis of Dry Eye Disease (DED), a combination of diagnostic tests have been used to assess its symptoms and clinical signs.[22] Therefore, CVS diagnosis is considered by exclusion. [12]

Dry eye disease is one of the most frequently faced ocular morbidities that may have a significant role in the occurrence of CVS. It is closely related to CVS either as a reason or consequence. [21] The discomfort associated with computer usage has a significant impact on visual function that can negatively affect the quality of worker's life and may cause a reduction in work accuracy and productivity by as much as 40 %. [23]

Dry eye disease is a multifactorial disease of the ocular surface with symptoms of discomfort, visual disturbance, increased osmolarity and instability of tear film. Together with a potential inflammation and damage of the corneal and conjunctival epithelium (ocular surface),[24] with the resultant discomfort of dry eye. [25]

The tear film is an interactive hydrated mucin gel, with lipid present on its surface, associated with proteins that are distributed throughout the mucin gel. [26] Moisture of the eye is maintained by the secretions of lipid and mucous.[27]

Tear hyperosmolarity which results from reduced flow and/or increased evaporation of the aqueous tear is considered a key step in the vicious circle of DED pathology. It gives rise to apoptosis of the conjunctival and corneal cells which triggers inflammatory cascades that contribute to further cell death and leading to loss of mucin-producing goblet cells. This exacerbates tear film instability and drives the cycle of events that perpetuate the condition.[24]

Although, dry eye is a symptom constituting CVS, [12] some computer users reported watery eyes among their complaints. This is explained by that the dryness of ocular surface stimulates the reflex arc of the 5^{th} and 7^{th} cranial nerves producing excess tears.[28]

Reflex tears are different in composition from the basic tears needed to lubricate the ocular surface. As it is aqueous, deficient of mucin needed for proper tear film and it do not control dryness; as it lead to more eye reaction and produce more reflex tears.[29]

Persons may complain from symptoms of dry eye in the presence or absence of signs of the disease.[25] About 90% of workers who are using computers for more than 3 hours per day experience the computer vision syndrome.[20,30] It is usually temporary and disappears at the end of the working day; however some workers may experience continuity of symptoms after work.

Without intervention, the majority of these symptoms will recur and also worsen in the future. [31] Consequently, there is an increasing public and scientific interest of studying the impact of natural and artificial electromagnetic fields on health. Therefore, there is an urgent need to understand and prevent the dynamics of these problems.[32]

Aim of study: to assess toxic effects of computer generated radiation on eyes among a sample of Egyptian computer users.

SUBJECTS & METHODS

Type of study and participants: this is a cross sectional study conducted on 100 volunteers of computer workers from both sexes who fulfilled the inclusion criteria and agreed to participate in the study (out of 150 computer workers at one of the Etisalat companies). All of them worked daily on the computer for duration of more than one year. The study was performed as a screening test for symptoms of computer vision syndrome in the form of dry eye disease. It was conducted during the period from the first of January 2014 to the end of December 2014.

Ethical consideration: The study was approved by the Ethical Review Committee at the Faculty of Medicine for girls; Al Azhar University. An informed verbal consent was obtained from all participants after they were reassured about the confidentiality of data and before starting of the study. The study was conducted after managerial permission.

Exclusion criteria: All of the following persons were excluded from this study. Persons who had history of intraocular surgery or LASIK (Laser Assisted in Situ Keratomileusis) correction of < 6 months duration, also those who have history of keratoconjunctivitis, nasolacrimal duct obstruction, Sjögren's syndrome, systemic lupus erythematosus or rheumatoid arthritis diseases. As well as, those using topical ophthalmic drugs and females who takes hormone replacement therapy.

Tool of the study: all participants were subjected to a self-filling questionnaire sheet in Arabic format which included two main parts. **Part I:**included questions about personal information (age, sex and wearing medical glasses or lenses), work and workplace related information (duration of daily computer usage and taking rest during computer work for at least 5 minutes/h, source of light, level of computer screen in relation to the eyes, distance between the eyes & computer screen, presence of light reflection on the screen as well as presence of fan or air conditioner).[33,34] **Part II:** included questions of the Ocular Surface Disease Index (OSDI) score for assessment of vision-related functions and dry eye disease (DED). According to ***Schiffman et al***[35] OSDI score is a valid & reliable tool for assessment of various aspects of dry eye disease and measuring DED severity (normal, mild, moderate and severe). The OSDI score demonstrates sensitivity and specificity in distinguishing between normal subjects and patients with dry eye disease. It permits quantification of common symptoms and provides a reasonably objective approach to the evaluation of symptoms over time therefore; it is a valuable tool in clinical treatment trials. OSDI score includes 12 questions about symptoms of eye and vision problems, the answer of each question is scored from (4 to 0) according to the subject complaint in relation to time (all of the time, most of the time, half of the time, some of the time and none of the time) respectively. OSDI score was assessed on a scale of 0 to 100 through calculating values by the following formula, in which higher scores representing greater eye affection.

$$\text{OSDI} = \frac{\text{Sum of scores of all questions answered}}{\text{Number of questions answered}} \times 25$$ [36]

Severity of DED was determined according to the calculated formula and the overall OSDI score. [37]

The ocular surface is considered:

1-Normal from (0-12 points)
2-Mild DED from (13-22 points),
3-Moderate DED from (23-32 points)
4-Severe DED from (33-100 points)

Consequently, the participants were divided; **Firstly** into two groups:

Group 1= participants without symptoms of dry eye disease (21 participants).
Group 2= participants with symptoms of dry eye disease (79 participants).

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Secondly, the group with DED was subdivided into 3 subgroups with (mild, moderate and severe dry eye disease).

Statistical analysis of data: the collected data were coded, fed to computer, organized and statistically analyzed using the Statistical Package for Social Science (SPSS) version 15.0. The results were presented by tables and figures. Qualitative (categorical) data were presented by frequency and percentage. Quantitative data were presented by mean ± SD.

Chi-square (X^2) test was used for the comparison between groups as regard qualitative data. Student *t-test* was used for comparison between means of two groups as regard quantitative variables. ANOVA (F) test was used for comparison between means of more than two groups for quantitative variables.

Logistic regression analysis was used to identify the most relevant risk factors according to the value of Wald chi-square test and the Odds ratio (OR) which indicates the strength of association between the risk factor and outcome. P-value ≤ 0.05 is considered statistically significant with confidence level 95%.

RESULTS

A number of 100 volunteers participated in this study, their age ranged from 20- 48 years, 76.0% of them were males and 24.0% were females. The duration of their daily computer usage ranged from 3- 15 hours/day and 71.0% of them not taking regular rest (for at least 5 minutes/hour of computer work) **(tables 1).**

More than three quarters (79.0%) of participants had symptoms of dry eye disease (of them 74.7 % males & 25.3% females).Also, 45.6% of participants with symptoms of dry eye disease were wearing medical glasses or lenses compared to 9.5% of those without symptoms of dry eye disease, with a significant p-value (< 0.05). Concerning the duration of daily computer usage/hours and taking rest during work (5minutes/h) there is no statistical significant difference (P > 0.05) between subjects with symptoms of dry eye disease and those without symptoms of dry eye disease **(figure1 &table 2)**.

Regarding characteristics of the workplace environment 79.7 % of those with symptoms of DED used electric lamp as a source of light and 24.1% recorded presence of light reflection on the screen. The level of computer screen was higher than eyes among 48.1% of those with symptoms of DED and 83.5% recorded that the distance between their eyes & screen was ≥ 30 cm. Meanwhile, most of participants (98.7%) with symptoms of DED had fan or air conditioner at the work place, with no significant difference between subjects with and those without symptoms of dry eye disease **(table 3)**.

Regarding the different quantitative eye scores and the OSDI score; comparison between participants with and those without symptoms of dry eye disease revealed a statistical significant difference (p-value< 0.05)**(table 4).**

Among participants who had symptoms of DED 40.5% had severe eye affection, 26.6 % had moderate and 32.9 % had mild eye affection **(figure 2)**. Participants with severe DED were using computer for a longer duration around 10 hour/day (10.3 ± 2.4) than those with mild or moderate eye affection with a significant p-value (< 0.05) **(table 5)**.

Logistic regression analysis demonstrated that wearing visual aids was the most significant risk factor relevant to the occurrence of dry eye disease (Odds ratio = 7.95) with significant level of p- value (< 0.05).Also, the presence of fan or air conditioner and the presence of light reflection on computer screen were relevant to the occurrence of dry eye disease (Odds ratio = 3.9 and 3.0 respectively) **(table 6)**.

DISCUSSION

Computers like all electronic devices generate an Electromagnetic Field (EMF) of non-ionizing radiation which releases energy. This energy exerts negative effects on human health especially those who using computers or even sitting in a computer workplaces. These radiations may cause several health hazards either rapidly or slowly.[38]The eyes & testicles are particularly vulnerable; this is because it have no high levels of blood flow. Therefore there is no mechanism for dissipating away heat generated in these organs by irradiation. [39]

Vision problems related to computer use include dry eyes, eye strain, burning sensations, redness of eyes, blurred and double vision were termed computer vision syndrome (CVS).[40]The most frequently occurring health problem among computer users are CVS.[41, 42]

Consequently, this study was designed and carried out among a sample of Egyptian computer users, in order to assess the toxic effects of the computer generated radiation on the eye.

According to the results of this study, the mean age of the studied sample (100 voluntary participants) was 28.3 ± 3.5 years, 76.0 % of them were males and 24.0 % were females. Regarding OSDI score calculation, more than three quarters (79.0%) of participants had symptoms or suffered from CVS (of them 74.7 % males and 25.3 % females) in the form of dry eye disease (DED).

Similar results were reported by ***Logaraj et al.***[42] who studied computer vision syndrome (CVS) among medical and engineering college students and found that CVS was prevalent among 81.9% of engineering students and 78.6% of medical students**.** Also, CVS was reported among 46.3 % [43] and 89.9 %[44] of college students at Malaysia.In addition ***Ziaei et al.***[45]stated that visual fatigue was prevalent among computer users as 45.4 % of them suffered from severe eye strain. Also, ***Zainuddin and Isa,***[31] reported that CVS was present among 63.0 % of administrative staff in the University Putra Malaysia. Moreover, ***Iwakiri et al.***[46] found that 72.1% of office workers in their self-reported survey were having eyestrain and/or pain. Along with, ***Rahman and Sanip,***[47] stated that 68.1% of their participants reported CVS symptoms.

The current study demonstrated that the mean duration of daily computer work was the longest (10.3 ± 2.4 hours / day) among participants with severe eye affection **(table 5).**This may possibly indicate that long duration of daily work on computer denoting more affection of eye by DED. This could be explained by the presence of the accommodation reflex of the eye which is an active process requiring muscular effort and is working as long as an individual working at the computer monitor .This leading to eye exhaustion, refractive error and development of computer vision syndrome symptoms.

Similarly, another study**,** found that working on computer for more than 7 hours/day predisposing a person to get CVS.[47]In addition, the ocular complaints were more reported among subjects who used computers for more than 6 hours a day.[33] Moreover, the students who were using computer for 4-6 h/day were at a significantly higher risk of developing symptoms of CVS compared to those who use computer for less than 4 h/day with a significant correlation between increased hours of computer use and the symptoms of CVS.[42]Additionally, the long duration of computer work is directly related to the eye symptoms and tended to result in long-lasting complaints which persist even after finishing the work.[48] Furthermore**,** ***Abdelaziz et al.***[49] mentioned that, people who spend more than 2 hours every day on a computer will experience symptoms of CVS. They explained that the light rays from a very near object to the individual's eye (like the case of computer users) cannot be brought to a focus on the retina. Also, the degree to which the lens curvature can be increased is limited even with the greatest effort. This strains the eyes especially the ciliary muscles that could affect the visual acuity. Another, study conducted on students from different universities at Malaysia revealed that students who used computer for more than 2 hours/day experienced significantly more symptoms of CVS.[44] Additionally; tasks that require mental effort in front of the computer screen for a long duration leads to decrease in the rate of blinking reflex and thus enhance the symptoms of CVS.Besides, a study conducted in USA among computer workers revealed a significant positive correlation between the score of visual symptoms related to computer use and the average number of hours spent in working on the computer within a day.[34] On contrary, another study reported that no correlation between asthenopia and the number of work hours on the computer /day. [43]

These differences between the studies regarding the relation between duration of computer use and the occurrence of CVS symptoms ; might be explained by weather variation between countries (as humidity level) and the different nature of work from study to another.

Concerning taking a rest break for 5 minutes / hour of computer work, it was found that nearly three quarters (70.9%) of participants with symptoms of DED did not take rest during work.

These results are in agreement with the study that reported significant association between long hours of computer work and the adverse health effects.[50] Moreover, it was stated that students who took a break every 2 hours of continuous computer work had a statistically significant higher risk of developing symptoms of CVS when compared to those who took a break every one hour.[42]Also, it was reported that, visual complaints were more among students who did not take frequent breaks from the computer work.[23] In

addition to that , burning sensation of the eyes and eye strains were significantly prevalent among subjects who did not take breaks during computer use.[33] This can be explained by the fact that the fixed position of eyes lead to eye fatigue due to continuous accommodation in addition to the glare from the computer screen. The high percentage of dry eye disease in the present study could be related to long working hours with inappropriate schedule for regular rest.Therefore, computer users are recommended to look at an object away from the screen at least once every ½ to 1 hour in order to prevent eye strain and helps muscles of the eye to relax, thus decreasing the eye fatigue and headache.[51]Also**,** ***Blaci and Aghazaden,***[52] stated that computer users should take 5 minutes rest for every 30 minutes of work or four times rest per hour of work to lessen eye symptoms.

On the contrary**,** ***Bhanderi et al.***[43]did not find any association between duration of computer use, frequency of taking breaks and the occurrence of asthenopia.

This study revealed that wearing medical glasses or lenses while using computer was reported among 45.6% of participants who had symptoms of DED, and it was the most relevant factor for occurrence of DED with statistical significant difference from participants without symptoms of DED ($P < 0.05$) **(table 2).**

Similarly other study stated that , students who wearing medical glasses experienced symptoms of DED significantly more often than those who were not wearing glasses.[44] Also, visual fatigue was higher among computer users who wearing glasses than those who not wearing glasses ($p < 0.001$). [45]

Another, studies reported that using of the glasses /lenses were significantly associated with CVS [47] and eye symptoms were significantly associated with the use of medical glasses. [48] Moreover, symptoms of CVS were more prevalent among those who wear the visual aids than among non-wearers of visual aids. [53]

The high prevalence of CVS among those using correction glasses/lenses may be explained by the nature of computer work with near vision and looking at small letters on the screen. This causes the eyes which already have some corrective problem to work slightly harder to keep the images in focus. In addition to local irritation caused by contact lenses and thus alter the blink rate significantly leading to a more unstable tear film.[54] In contradiction to the previous, it was found that ocular complaints were more frequent among subjects who did not use glasses.[32]

Regarding the source of light in the work place results of this study demonstrated that the majority of both groups of participants with and without symptoms of DED (79.7 % and 85.7 % respectively) used lamp light in the work place without significant difference between the studied groups.

Similarly ***Reddy et al.***[44]found that 81.6% of the studied students used fluorescent light in the room; 13.3% utilized natural sunlight available in the room; 2.8% used other forms of lighting; and 2.3% worked without any light in the room while working on the computer. These differences between their studied groups regarding the presence of CVS and the use of fluorescent lighting in the room were not statistically significant.

Additionally, **this study revealed that** 24.1% of participants with symptoms of DED reported presence of light reflection on the screen while working on computer and is considered as a relevant factor for the occurrence of DED symptoms (odds ratio = 3.0).

Regarding to the level of computer screen in relation to user`s eyes, this study revealed that 48.1% of participants with symptoms of DED mentioned that computer screen was at a higher level than their eyes. These results are in agreement with the study that reported increased symptoms of CVS among students who looked at the computer screen at a higher level than their eyes in comparison to students who looked at the computer screen on the same level of eyes.[42]Moreover, ***Bhanderi et al.*** [43] found a significantly higher proportion of asthenopia among those whose computer screen at or above the eye level.Another studies stated that eye complaints were less when the subjects maintained the top of screen level below the eyes.[14, 33] Furthermore, there was significant reduction in symptoms of CVS between students who viewed the computer screen below eye level than those who viewed the screen at or above the eye level. [44]

The computer screen level is usually located higher than the users' watching level, which makes the palpebral fissure more open and results in dryness of the eyes.

Concerning the distance between the eyes and computer screen, the current study demonstrated that the majority (83.5%) of

participants with symptoms of DED used the computer screen at a distance ≥ 30 cm.

In the same context another study revealed that symptoms of dry eye was more among students placing the computer screen at a distance less than 50 cm and these complaints decreased with the viewing distance increased.[23] Also, a study carried out on 416 students, reported that the risk of developing CVS were higher among students who used the computer at a distance of less than 50 cm.[42] Furthermore, a significant higher rate of asthenopia, eye strain and headache were found among subjects who did not maintain a proper distance of 20-24 inches from the computer.[15,33]

On opposition, asthenopia was less among subjects whose viewing distance from the screen was more than 30 cm while it was the highest when the viewing distance was less than 30 cm (12 inches), with a statistically significant difference. [43]

Explanation of this could be related to that, user's concentration on computer screen decreases the speed of blinking and the eye exposed to free air, thereby causing redness, burning, tiredness and eyestrain. Additionally, the close distance between the eyes and screen causes an excess accommodation with overworking of the ciliary muscles of the eye, leading to symptoms of CVS like eye fatigue and headache.

About the presence of fan or air conditioner in the workplace, results of this study demonstrated that most of participants with symptoms of DED (98.7%) reported presence of fan or air conditioner at their workplace and it was a relevant factor for the occurrence of DED symptoms. This is in accordance with, ***Rosenfield,***[55] who mentioned that environmental conditions including settings of air conditioning or the use of ventilation fans produce corneal dryness.

Computer vision syndrome considered a common problem among computer users but the symptoms often ignored and neglected. Persistence of this problem without correction could reduce job performance and satisfaction. **Accordingly**, it is recommended that: Computer users should take a break for 5–10 minutes every continuous hour of work to reduce muscle tension and fatigue and to follow the 20/20/20 rule, which means that after 20 minutes of computer work a person must look away at 20 feet for at least 20 seconds. Also, use artificial tear drops and pay attention to blinking of eyes to moisten the eyes, to keep hydration and lubrication of the ocular surface. Avoid presence of light reflection on computer screen and the direct effect of fan or air conditioner at the workplace. Use flat screens whenever possible with an anti-glare. Keep the computer screen away from the eyes by 20 to 24 inches and the level of the computer screen should be 5-6 inches below the straight line of the users' vision.[12] Adjust the computer screen brightness to be approximately the same as the brightness of the surroundings. Hence health education regarding good working practices is essential to avoid or minimize severity of dry eye disease symptoms. **Finally,** further studies are recommended with larger samples and clinical ophthalmological tests aiming at clinical evaluation and confirmation of the diagnosis of dry eye disease and computer vision syndrome.

CONCLUSION

More than three quarters of the studied computer users suffered from vision related symptoms of dry eye disease. Those who have errors of visual refraction and wearing visual aids as well as those who use the computer for around 10 h / day without regular rest are more vulnerable to dry eye disease .Also, the presence of fan or air conditioner in the workplace and the presence of light reflection on computer screen increase the degree of eye dryness. Long duration of daily computer use was associated with higher values of OSDI score denoting more affection of eye by dry eye disease. Ocular surface disease index score considered an easy, fast and reliable method for assessment of toxic effect of the generated electromagnetic radiations from the computer on the eye.

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Table (1): General characteristics of the studied computer workers

Items		Total No. =100
Age/years	Mean ± SD Range	28.3 ± 3.5 20 - 48
Sex	-Male -Female	76 76.0 % 24 24.0 %
Wearing medical glasses or lenses	- No - Yes	62 62.0 % 38 38.0 %
Duration of daily computer usage/hours	Mean ± SD Range	9.12 ± 2.3 3 - 15
Taking rest during work (5 minutes/h)	- No - Yes	71 71.0 % 29 29.0 %

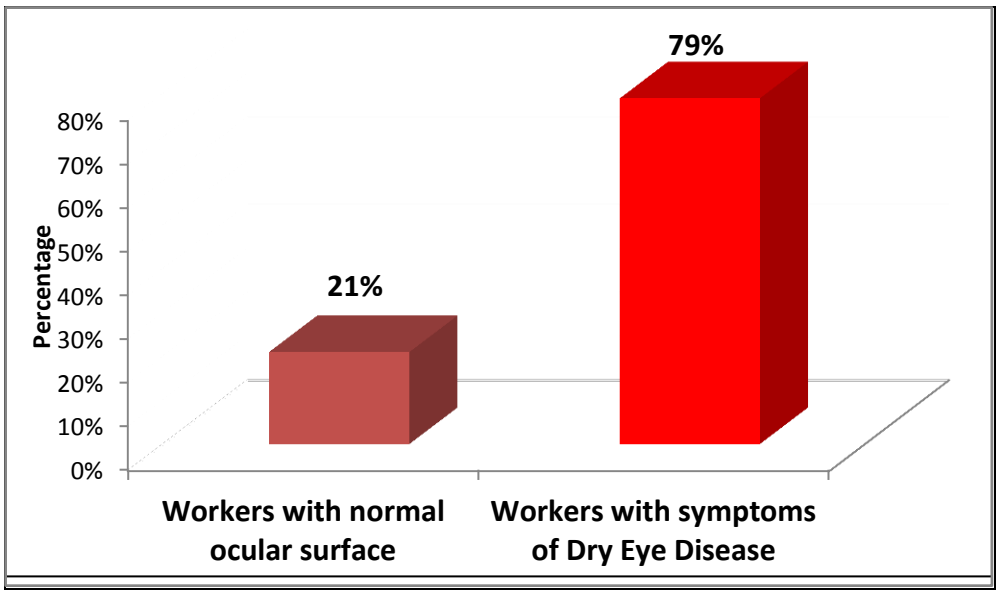

Figure (1): Distribution of participants according to the presence of dry eye disease symptoms

Table (2): Distribution of participants regarding general characteristics according to the presence of dry eye disease symptoms

Groups Items		Participants without symptoms of DED No. = 21	Participants with symptoms of DED No. = 79	Sig. test & p-value
Age/years	Mean± SD Range	28.9 ± 3.2 24 – 38	28.3 ± 3.6 20 - 48	*t-test* =0.74 P = 0.45
Sex	Male Female	17 81.0 4 19.0	59 74.7 20 25.3	Chi-square (X^2) *test* = 0.3 P = 0.5
Wearing medical glasses or lenses	No Yes	19 90.5 2 9.5	43 54.4 36 45.6	Chi-square (X^2) *test* = 9.14 P = 0.002*
Duration of daily computer usage/hours	Mean ± SD Range	9.0 ± 2.3 3 - 13	9.15 ± 2.4 3 -15	t-test = 0.25 P = 79
Taking rest during work(5minutes/h)	No Yes	15 71.4 6 28.6	56 70.9 23 29.1	Chi-square (X^2) *test* = 0.002 P = 0.9

*Significant p-value **DED:** Dry Eye Disease

Table (3): Characteristics of the workplace environment in relation to the presence of dry eye disease symptoms

Groups / Items	Participants without symptoms of DED No. = 21		Participants with symptoms of DED No. = 79		Sig. test & p-value
	No.	%	No.	%	
Source of light					Chi-square
Lamp light	18	85.7	63	79.7	(X^2) *test* = 0.3
Sun light or combined	3	14.3	16	20.3	P = 0.53
Presence of light reflection on the screen					Chi-square
No	19	90.5	60	75.9	(X^2) *test* = 2.1
Yes	2	9.5	19	24.1	P = 0.14
level of computer screen in relation to the eyes					Chi-square
Higher than eyes	14	66.7	38	48.1	(X^2) *test* = 2.29
Below eyes	7	33.3	41	51.9	P = 0. 13
Distance between the eyes &computer screen					Chi-square
< 30 cm	2	9.5	13	16.5	(X^2)*test* = 0.62
≥ 30 cm	19	90.5	66	83.5	P = 0.4
Presence of fan or air conditioner					Chi-square
No	1	4.8	1	1.3	(X^2)*test* = 1.0
Yes	20	95.2	78	98.7	P = 0.3

Table (4): Distribution of different quantitative eye scores and Ocular surface disease index according to presence of dry eye disease

Groups / Items	Participants without symptoms of DED No. = 21	Participants with symptoms of DED No. = 79	Sig. test &P-value
Quantitative score of ocular discomfort			t-test= 6.3
Mean ± SD	1.6 ± 1.4	7.0 ± 3.8	P = 0.000*
Quantitative score of visual function			t-test= 3.8
Mean ± SD	0.8 ± 1.6	3.5 ± 3.0	P = 0.000*
Quantitative score of environment effect			t-test= 4.17
Mean ± SD	1.2 ± 2.18	3.6 ± 2.4	P = 0.000*
Ocular surface disease index (OSDI)			t-test= 7.0
Mean ± SD	6.2 ± 3.7	31.4 ± 16.0	P = 0.000*

*significant p-value

Table (5): Different grades of eye affection in relation to duration of computer usage and Ocular surface disease index

Degree of DED Items	Mild eye affection No.= 26	Moderate eye affection No.= 21	Severe eye affection No. = 32	Sig. test & P-value
Duration of computer usage (hours \day)				F-test= 6.68
Mean ± SD	8.15 ± 2.15	9.19 ± 2.2	10.3 ± 2.4	
Range	3 – 12	4 - 15	3 - 15	P = 0.002*
Ocular surface disease index (OSDI)				F-test= 139.1
Mean ± SD	15.3 ± 2.4	26.2 ± 3.2	47.8 ± 11.3	
Range	13 -20.8	22.7- 32.0	33 - 75	P =0.000*

*significant p-value F-test = Analysis of variance (ANOVA) test

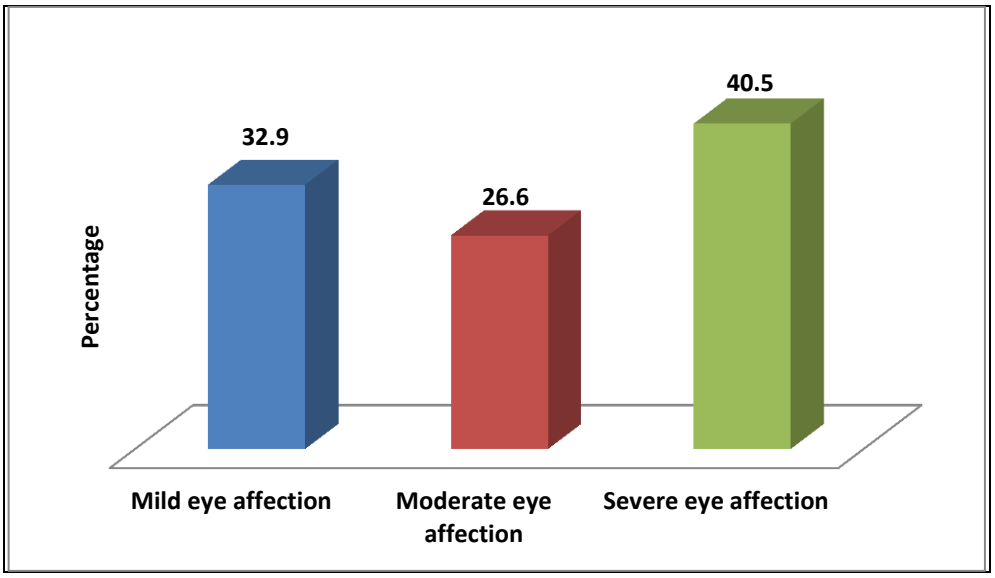

Figure (2): Percentage distribution of participants having symptoms of dry eye disease according to the degree of eye affection

Table (6): Logistic regression analysis of the most relevant factors to the occurrence of dry eye disease

Items	Wald Chi -square (X^2) test	Odds ratio	P-value
Wearing visual aids	4.9	7.95	0.02*
Presence of fan or air conditioner	3.35	3.9	0.06
Reflection of light	2.28	3.0	0.13

*significant p-value