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Effect of Interactive Digital-based Educational Intervention about Digital Eye Strain on the Severity of Eye Complaints, Knowledge and Preventive Ergonomic Practices among Computer Users

Samiha Hamdi Sayed*, Amel Youssef Abd El Wahed, Abeer Abd-El Aziz Mohamed Madian

Community Health Nursing, Faculty of Nursing, Damanhour University, Egypt
*Corresponding author: Samiha.Hamdi@nur.dmu.edu.eg

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Abstract **Background**: Digital Eye Strain is major health complains among computer users in the new era of advanced technology with predominant poor knowledge and ergonomics. **Aim**: Evaluate the effect of interactive digital-based educational intervention about digital eye strain on the severity of eye complaints, knowledge and preventive ergonomic practices among computer users. **Design:** A randomized control educational trail design was employed (pre-post-test control group). **Setting:** the study was fulfilled in the main administrative building of Damanhour University/Egypt. **Participants:** 140 randomly selected computer users' employees working in the study setting. **Tools:** four tools were used for data collection. **Results**: a statistically significant mean difference was found regarding total eye complaints score after one month and three months of the educational intervention. The total knowledge score and the total preventive ergonomic practices score showed a highly statistically significant mean difference after one month and three months of the educational intervention. Moreover, the total workstation design score revealed a statistically significant mean difference after one month and three months **Conclusion** the research hypothesis was accepted as the interactive digital-based educational intervention about digital eye strain and its preventive ergonomic practices was effective in reducing the studied computer users' reported eye complaints also enhancing their knowledge level about digital eye strain in additionally modifying their preventive ergonomic practices and workstation design. Hence, it is **recommended** to develop hotlines and web-based educational sites for digital users to help them in facing the rising epidemic of digital eye strain associated with the new era of advanced technology.

Keywords: *digital eye strain, interactive digital-based education, knowledge, ergonomic practices, computer users*

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1. Introduction

Using digital devices has become an imperative part of every daily life. The use of technology has improved rapidly since 2011 from 52% to 77.5% while those who are classified as modern users have become more than double [1]. Henceforth, the utilization of visual display terminals especially computers becomes a necessity in the 21st century where it has been used regularly in numerous institutions as governmental offices, academic, and banking organizations. However, every advancement has its own drawbacks or adverse effect on human health where recent evidence shows that the routine and regular use of personal computers and digital screens on daily basis for 3 hours or more increases the risk of developing several health problems as Occupational Overuse Syndrome (OOS), migraine, psychosocial tension and Digital Eye Strain (DES) [2,3,4]. The American Optometric Association (AOA) identified the DES as a complex of eye and vision problems arising from behaviors that stress near vision during computer or digital screen use. It also recognized as Computer Vision Syndrome (CVS), Asthenopia or eye strain which describe any vision deficiency stems from contact with the digital screen or computer monitor and their environment. Today, DES is considered as one of the chief occupational hazards especially among office workers [5,6]. The prevalence of DES has received greater attention in scientific literature due to the technological revolution. Latest data suggest that DES is a momentous problem disturbing multiple millions of people. A recent report from the vision council in 2018 found that after using electronic devices for two hours per day or more, 59% of adults' American reports having DES [1,7]. The Institute of Occupational Safety and Health (OSH)

ascertains that DES is an unintended consequence associated with prolonged computer use unless suitable ergonomic principles were followed. In 2018, OSH endorsed that about 64- 90% of computer users experienced symptoms of DES especially those who spend about three hours or more per day on computers and further explored that around 88% of them will get DES at any time of life [8].

Digital Eye Strain is a term used to designate a set of accompanying both external and internal symptoms. External symptoms encompass irritation, burning sensation, discomfort, tearing, and dryness besides neck and shoulders pain while internal symptoms include strain, ache, and headache behind the eyes. A clear division of computer-related symptoms was classified into two categories: accommodation-related symptoms (i.e. blurry close vision, blurred distance vision after computer use, and trouble refocusing from one distance to another) and dry eye-related symptoms (irritation/burning sensation, eye strain, headache, tired eyes, sensitivity to intense light and eye discomfort) [9,10,11].

Several risk factors may be responsible for the occurrence and progression of DES. Internal symptoms associated risk factors are chiefly related to the existence of untreated pre-existing eye problem as astigmatism, ametropia or refractive errors as far or nearsightedness and poor accommodation. However, risk factors for external symptoms of DES are mainly related to faulty ergonomic practices such as uncomfortable position, prolonged viewing of digital screens, improper lighting conditions, uncommon blinking, glare and incorrect distances between the eye and the device. Evidently, recent studies showed that the utmost digital users have unsatisfactory knowledge about DES and preventive ergonomic practices. This can highlight the reasonable need for establishing fitting educational intervention to face the rising trend of DES using suitable Information and Communication Technologies [9,12,13]. The revolution of information and communication technologies denotes the use of technologies that offer telecommunications access to information. It has endorsed as an effective appliance for promoting health and sensitizing behavior change. Digital Health Interventions (DHIs) are programs that delivered information and support for physical and/or mental health issues via a digital podium (computers, mobile phones, Websites, desktop computer programs, or apps). Plentiful systematic reviews have approved the probable efficiency of DHIs in health promotion through enhancing health behaviors and outcomes. It can help in the provision of a convenient entryway for accessing tailored and private health information for digital screen users which can be employed to enhance workers' occupational health [14,15]. The occupational health focuses principally on workers' health preservation and promotion, improvement of their working capacity and creating conducive working environment to safety and health standards. These necessitate a multidisciplinary approach through a professional occupational health team where the Community Health Nurse (CHN) is a pivotal member who can work for the prevention of DES and enhancement of safe ergonomic principles. She can conduct a careful risk assessment of possible individual and environmental risk factors; encourage and participate in conduction of annual ophthalmological examination to discover refraction problems or binocular vision after the age of forty and refer high-risk groups accordingly. She also can conduct counseling for proper healthy lifestyles especially sleep quality to decrease overall fatigue. CHN can work to sensitize the organizational management system about the problem to enforce proper preventive infrastructural measures. As a health educator, CHN is in a strategic position to cultivate and conduct personalized educational programs that afford tailored health information about DES and safe preventive ergonomic practices to face the rising epidemic of DES associated with technological advancement [4,16,17].

1.1. Significance of the Study

The Digital Eye Strain is a rising epidemic facing the world as a negative unintended consequence of improper use of technological advancement. It was proved that DES can contribute to the reduction of employees' quality of life and work accurateness which further can diminish work productivity [3]. Hence, working to eliminate DES is a necessity for community development. Unfortunately, recent evidence explored a prevalent poor knowledge about DES and its preventive ergonomic practices. Dessie A et al (2018) performed a study in Ethiopia to assess DES and its concomitant factors among computer users. The study portrayed knowledge as a significant predictor of DES where those who had good knowledge about safety measures for computer use had less frequent eye symptoms [12]. Lizette M et al (2017) assessed ergonomic practices and eye symptoms among undergraduate college students and portrayed a significant negative correlation between symptoms of DES and ergonomic practices [13]. Consequently, this stimulates action to combat the problem by establishing tailored and interactive educational intervention for computer users to aid in improving their ergonomic knowledge and practices.

1.2. Aim of the Study

- Evaluate the effect of interactive digital-based educational intervention about digital eye strain on the severity of eye complaints, knowledge and preventive ergonomic practices among computer users.

1.3. Research Hypothesises

1- Computer users who receive the educational intervention about DES and its preventive ergonomic practices exhibit lower severity of reported eye complaints.

2- Computer users who receive the educational intervention about DES and its preventive ergonomic practices exhibit a higher knowledge level.

3- Computer users who receive the educational intervention about DES and its preventive ergonomic practices exhibit safe preventive ergonomics practice.

2. Materials and Methods

2.1. Research Design

A randomized control educational trail design (pre-post-test control group) was utilized.

2.2. Setting

The study was accomplished at the main administrative building of Damanhour University due to the highest percent of computer users.

2.3. Subjects

Computer users' employees working at the prementioned setting. They were selected to be compatible with the next inclusion criteria [18,19]:

- Using computers for at least one year
- Using computer continuously for at least 3 hours or more per day
- Possessed a Smart Mobile phones
- Willing to participate in the study.

2.4. Sampling Technique

The study sample comprised of 140 randomly selected computer users' employees by lottery method working at the main administrative building of Damanhour University. Each one of the selected computer users (140) was randomly assigned to either a study (70) or control group (70).

2.5. Sample Size

It was computed using EPI info 7 software according to the average number of employees in the administrative building of Damanhour university (372), 50% expected frequency with an acceptable error of 5% and confidence limit of 95%. This resulted in a minimum requisite sample size of 125. The ultimate sample size was 140 employees to recompense the probable non-response.

2.6. Tools for Data Collection

Four tools were utilized:

Tool I: Computer User's Structured Questionnaire Sheet

It was developed by the researchers after a thorough review of relevant recent literature and alienated into two parts as follows: -

Part 1: - Personal and Computer Use Related Data

- Personal characteristics: age, gender, and educational level
- Medical history: co-morbidity, history of eye problem, history of eye surgery, previous ophthalmologist consultation for any eye problem and medication use.
- Computer use related data: duration of computer use/years, daily use/hours and use of eyeglasses or lenses during computer use.

Part 2: Assessment of Self-Reported Eye Complaints [20]

It composed of 20 self-reported items classified as visual (4), ocular (8), light (3) and general (5) symptoms. They were rated on a three-point Likert scale to indicate how often computer users had suffered from any eye complaints in the previous month; (0) never, (1) occasionally, (2) frequently. The total score was calculated and ranged from 0 to 40; it was categorized into three levels as follows:

- Mild < 50% (0<20)
- Moderate 50% <75% (20<30)
- Severe ≥ 75% (≥ 30)

Tool II: Computer Users' DES Knowledge Scale

It consists of 46 items about DES; definition, causes, manifestations and safe preventive ergonomic practices. The correct answers were pre-determined according to the literature and scored as follows: (1) correct answer, (0) incorrect or unknown answers. The total knowledge score was calculated and ranged from 0 to 46 which further categorized into three levels [5,21,22]:

- Poor knowledge < 50% (<23)
- Fair knowledge 50% < 75% (23<35)
- Good knowledge ≥ 75% (≥ 35)

• The question about the awareness about DES wasn't included in the total score.

Tool III: Ergonomic Practices and Workstation Design Observational Checklist

It was constructed based on the American Optometric Association (AOA) [5] recommended guidelines for prevention of DES. It included two parts as explained in the following: -

Part 1: Assessment of the computer users' preventive ergonomic practices

It composed of 17 items distributed over 8 dimensions as follows: location of computer screen (2), display settings (3), reference materials (2), lighting (3), anti-glare screen (1), seating position (3), rest breaks (2), and blinking (1). The total observational score was rated on three-point Likert scale; (2) accurately done, (1) inaccurately done, and (0) not done which creating a total score ranged from 0 to 34. The total score was further categorized into three levels as follows [5,19]:

- Poor practice < 50% (<17)
- Fair practice 50% < 75% (17<26)
- Good practice ≥ 75% (≥ 26)

Part 2: Assessment of the Computer Workstation Design

It included 14 items covering 6 dimensions as follows; computer screen (4), anti-glare screen (1), lightening (3), document holder (3), desk (1) and chair (2). Every item was scored (2) if present, (1) if absent, and (0) if not applicable. The total observational score for computer workstation design was calculated and ranged between 0 - 28 and categorized into three levels as follows [5,20]:

- Poor workstation < 50% (<14)
- Fair workstation 50% < 75% (14<21)
- Good workstation ≥ 75% (≥ 21).

Tool IV: Satisfaction Scale with the Interactive Digital-Based DES Educational Intervention

It was developed by the researchers and comprised 14 items distributed over 4 dimensions as follows: program objectives (2), content (4), content presentation methods (5) and usefulness of the program (3). Each phrase was rated on five-point Likert scale; strongly disagree (1), disagree (2), neutral (3), agree (4) to strongly agree (5). The total score was computed and ranged from1 to 70 and categorized into three levels as follows [23]: -

- Dissatisfied < 50% (<35)
- Moderately satisfied 50% < 75% (35<53)
- Highly satisfied ≥ 75% (≥ 53).

3. Methods

3.1. The Study Was Accomplished According to the Following Steps

1. **Permission:** an official letter from the Faculty of Nursing was directed to the responsible authority of the administrative building of Damanhour University to take their consent for collecting the data after explicating the study aim.
2. **Tools development:** all Tools (I, II, III, IV) were developed by the researchers based on a review of relevant recent literature.
3. **Tools Validity:** all the study's tools were examined for content validity by a jury of five experts in the field of community health nursing from Faculty of Nursing; Damanhour University and the suggested adjustments were done.
4. **Tools Reliability:** the reliability test was conducted using Cronbach's Alpha and the tools seem to be reliable: self-reported eye complaints (Tool I/part2: r =0.85), DES knowledge scale (Tool II: r= 0.79), preventive ergonomic practices observational checklist (Tool III/part1: r = 0.80), computer workstation design observational checklist (Tool III/part2: r= 0.84) and satisfaction with the program scale (Tool IV: r = 0.89).
5. **Pilot study:** twenty computer users were piloted to ascertain the clarity, applicability, and feasibility of the tools and to detect the obstacles that might impede the data collection process (no included in the original sample). Consequently, all needed modifications were done.
6. **Data collection process:** the overall data collection process took about nine months (from August 2018 to April 2019).

- Pre-assessment of computer users' personal and computer use related data and medical history for both the study and control groups was done by the researchers once using tool I/part 1.
- Pre-test was done at August 2018 for both the study and control groups to assess the computer users' eye complaints (tool I/part 2), DES knowledge scale (tool II) and preventive ergonomic practices and workstation design (tool III).
- Program implementation was conducted over a period of two months from September to October 2018
- Post-test evaluation of the program was executed after one month at December 2018 and after three months at April 2019 using the same tools [Tool I/part 2, Tool II, tool III].

7. **Program:** the interactive digital-based educational intervention program was developed and implemented according to the following phases: -

I. Assessment phase:

- The researchers visit the study setting (the administrative building of Damanhour University) and explain the questionnaire to both the study and control group. It was distributed to be completed by both groups as pre-test.

- The observational assessment was conducted by the researchers for both study and control groups to assess their preventive ergonomic practices and workstation design using Tool III.

- The researchers get the e-mail address and phone number from each computer users in the study group to follow them throughout the study period and to solve any encountered problem during program implementation.

II. Planning phase

The interactive digital based DES educational intervention was developed by the researchers for the study group according to the following steps: -

a. Setting the program objectives

• **General objective:**

To improve the knowledge and practices of computer users for prevention of digital eye strain and decrease eye complaints.

• **Specific objectives;** By the end of this program the computer users will be able to: -

- Define Digital eye strain (DES)
- List the causes of DES
- Mention the possible signs and symptoms of DES
- Discuss the safe ergonomic practices for prevention of DES
- Apply the safe ergonomic practices for prevention of DES
- Modify the computer workstation design to prevent DES

b. Preparation of the content

- The content of the interactive digital-based DES educational intervention was designed by the researchers to cover all the predetermined objectives. It was developed based on review of relevant recent literature, results of pre-assessment as well as characteristics of computer users and their eye complaints.
- The content was comprised the subsequent: - definition, causes and possible signs and symptoms of DES. In addition to, the safe ergonomic practices for DES prevention and the proper computer workstation design.

b. Designing the presentation methods of the program content: numerous interactive digital-based methods were utilized as Electronic-Mail and WhatsApp. The content is displayed after designation using text along with fixed and animated graphics, hypertext, PowerPoint presentation and videos. The researchers also construct a WhatsApp broadcast group for the study group to facilitate communication on daily basis either in written format or using audio messages.

III. Implementation phase

- The designed content of the program was uploaded to the computer users through their e-mails, and WhatsApp application.
- Daily short health messages were sent to all computer users of the study group through WhatsApp application which includes information about DES and its preventive ergonomic practices.
- The researchers were available 24/day and 7days/week to answer any questions from the computer users to ascertain the interactive learning.

IV. Evaluation phase:

- Evaluation of the program was done two times; after one month (December 2018) then after three months of the completion of the program (April 2019) for the study group by sending electronic email of the post-test using the following

tools: - Eye complaints scale (Tool I/part 2) and DES Knowledge scale (Tool II).

- Post-test was done for the control group at their workstation one month and three months after the program completion by using the same tools: Tool I/part 2 and Tool II
- The researchers conducted the observational assessment of the study group's preventive ergonomic practices and computer workstation design (Tool III) during post-test of the control group.
- The effectiveness of the program on computer users' eye complaints, knowledge and preventive ergonomic practices for prevention of DES was measured through comparing the variance between pre-post-test mean total scores between the study and control groups.
- Satisfaction of the study group with the Interactive Digital-Based DES educational intervention was evaluated at the end using tool (IV).

3.2. Ethical Consideration

Informed oral consent was attained from each computer user after explaining the study aim. Their privacy and withdraw freedom from the study at any time were realized preceding the start of the study. Privacy and confidentiality were maintained during the process of data collection. The assurance of personal privacy of the study group during communication was assured on the designed WhatsApp group through instructing them to ask any needed personal questions on the researchers' private page or via e-mail to assure the participant privacy. After the end of the program, the designed digital content was delivered for the control group via their e-mails.

3. Statistical analysis: the collected data then was revised, categorized, coded, computerized, tabulated and analyzed using Statistical Package of Social Sciences (SPSS) version 20. The next statistical procedures were employed:

- Descriptive: number, percentage, arithmetic mean, standard deviation and bar graph.
- Inferential: the mean change in the overall score of the studied variables was employed for comparison at baseline and follow up after the educational intervention based on the total maximum allowable score for each variable, using the independent sample t test. Pearson correlation coefficient was utilized to appraise the correlation between two proportions.
- The cut off value (P value) statistical significance alienated for the current study was 0.05.

4. Results

Table 1 illustrates that the highest percent of both the study (68.6%) and control (67.1%) groups aged between 20<30 with nearly similar mean age (27.03 ± 6.80, 27.86 ± 9.32 respectively) with no statistically significant difference between both groups (X^2=4.635, P= 0.201). Most of both the study (70.0%) and control (62.9%) groups are males with no statistically significant difference between both groups (X^2=0.801, P= 0.371). University educational level is prevalent among 65.7% of the study group and 68.6% of the control group with no statistically significant difference between both groups (X^2=0.933, P= 0.421). No health problems are found among 75.7% of the study group and 78.6% of the control group with no statistically significant difference between both groups (X^2=2.124, P= 0.346). The majority of both the study (80.0%) and control (91.4%) groups has no history of eye problem with a statistically significant difference between both groups (X^2=3.733, P=0.053). Most of both the study (85.7%) and control (91.4%) groups has no previous ophthalmologist consultation with no statistically significant difference between both groups (X^2=1.129, P= 0.288). No previous eye surgery is found among 81.4% of the study group and 94.3% of the control group with a statistically significant difference between both groups (X^2=5.423, P= 0.020). Lastly, no medications use is found among most of the study (90.0%) and control (95.7%) groups with no statistically significant difference between both groups (X^2=1.723, P= 0.189).

Table 2 depicts that the duration of computer use is ranged between 5<10 years among 45.7% of the study group with a mean number of years 7.24 ± 3.98 compared to 32.9% among the control group with a mean number of years 6.77 ± 4.78 with a statistically significant difference between both groups (X^2=10.769, P= 0.005). Daily computer uses for 3<5 hours is revealed among 71.4% of the study group and 57.1% of the control group with a mean of 3.27 ± 1.08 and 4.41 ± 3.65, respectively with a statistically significant difference between both groups (X^2=19.98, P= 0.000). Most of the study group (90.0%) and 77.1% of the control group don't use eye glasses during computer use with no statistically significant difference between both groups (X^2=3.213, P= 0.632). The entire study group and 95.7% of the control group don't use contact eye lenses during computer use with no statistically significant difference between both groups (X^2=2.475, P= 0.479).

Figure 1 revealed that the majority of both the study (97.1%) and control (87.1%) groups has no preceding awareness about DES with no statistically significant difference between both groups (X^2= 0.834, P= 0.078).

Table 3 portrays that the entire study group's total eye complaints score at baseline is either at moderate (57.1%) or severe (42.9%) level while at follow up after one month all of them are at moderate level whereas after three months 78.6% of them are at mild level. However, the control group at baseline and follow up after one month and three months is at moderate level (74.3%, 72.9%, 77.1% respectively). Regarding total knowledge score of the study group at baseline is at the level of either moderate (61.4%) or poor (38.6%) knowledge level while the highest percent of them at follow up after one month (71.4%) and three months (60.0%) are at good knowledge level. In converse, moderate knowledge was found among the control group at baseline and follow up after one month and three months (81.4%, 71.4%, 50.0%, respectively). Pertaining to the total score of the preventive ergonomic practices, the highest percent of the study group at baseline is at poor level (88.6%) whereas good level is revealed among most of them at follow up after one month (71.4%) and three months (81.4%).

However, the control group at baseline and follow up after one month and three months is at poor level (77.1%, 90.0%, 80.0%, respectively). Concerning total workstation design score, 71.4% and 50.0 % of the study group are at fair level at baseline and follow up after one month respectively, whereas at follow up after three months most of them (94.3%) of them are at good level. However, the control group at baseline and follow up after one month and three months is at fair level (81.4%, 71.4%, 71.4%, respectively).

Table 4 portrays no statistically significant mean difference between both the study and control groups' total eye complaints score before the educational intervention (t= 0.604, P=0.079) however a statistically significant mean difference is depicted after one month (t= 17.691, P=0.001) and three months (t= 25.875, P=0.000) of the educational intervention. No statistically significant mean difference between both the study and control groups' total knowledge score before the educational intervention (t= 0.993, P=0.062) meanwhile a highly statistically significant mean difference is revealed after one month (t= 31.72, P=0.000) and three months (t= 18.025, P=0.000) of the educational intervention. No statistically significant mean difference is found between both the study and control groups' total preventive ergonomic practices score before the educational intervention (t= 0.294, P=0.588) however a highly statistically significant mean difference is observed after one month (t= 50.845, P=0.000) and three months (t= 29.032, P=0.000) of the educational intervention. Finally, no statistically significant mean difference is implied between both the study and control groups' total workstation design score before the educational intervention (t= 2.798, P=0.097) in converse a statistically significant mean difference is displayed after one month (t= 14.135, P=0.019) and three months (t= 14.135, P=0.000) of the educational intervention.

Table 5 shows that total eye complaints score of the study group before the educational intervention has highly statistically significant negative correlation with total preventive ergonomic practices (r=-0.438, P=0.000) and total workstation design (r=-0.309, P=0.000) and total knowledge score (r=-0.316, P=0.000).

Table 6 illustrates that 71.4% of the study group is highly satisfied with the interactive digital-based DES educational intervention. Specifically, the highest percent of the study group is strongly agreed with the program objectives (52.9%), program content (58.6%), the content presentation methods (54.3%) and usefulness of the program (60.0%).

Table 1. Distribution of the studied computer users according to their personal characteristics and medical history

Personal characteristics and medical history	Study Group (N=70)		Control Group (N=70)		Test of significance
	No.	%	No.	%	
Age (years)					
- 20-	48	68.6	47	67.1	X^2= 4.635 P= 0.201
- 30-	18	25.7	13	18.6	
- 40-	4	5.7	7	10.0	
- ≥50	0	0.0	3	4.3	
Min. – Max.	**20.0 – 53.0**		**20.0-50.0**		
Mean ± SD.	**27.03 ± 6.80**		**27.86 ± 9.32**		
Gender					
- Male	49	70.0	44	62.9	X^2= 0.801 P= 0.371
- Female	21	30.0	26	37.1	
level of education					
- University education	46	65.7	48	68.6	X^2= 0.933 P=0.421
- Secondary education	24	34.3	22	31.4	
Presence of health problems					
- No	53	75.7	55	78.6	X^2= 2.124 P= 0.346
- Yes	17	24.3	15	21.4	
History of eye problem					
- No	56	80.0	64	91.4	X^2= 3.733 P= 0.053*
- Yes	14	20.0	6	8.6	
Previous Ophthalmologist consultation					
- No	60	85.7	64	91.4	X^2= 1.129 P=0.288
- Yes	40	14.3	6	8.6	
Previous eye surgery					
- No	57	81.4	66	94.3	X^2= 5.423 P=0.020*
- Yes	13	18.6	4	5.7	
Medications use					
- No	63	90.0	67	95.7	X^2= 1.723 P=0.189
- Yes	7	10.0	3	4.3	

X^2 Chi square test *Statistically significant at ≤ 0.05.

Table 2. Distribution of the studied computer users according to computer use related data

Items	Study Group (N=70)		Control Group (N=70)		Test of significance
	No.	%	No.	%	
Duration of computer use (years)					
- < 5	17	24.3	21	30.0	X^2= 10.769 P=0.005*
- 5-	32	45.7	23	32.9	
- 10-	19	27.1	23	32.9	
- 15+	2	2.9	3	4.3	
Mean ± SD.	**7.24 ± 3.98**		**6.77 ± 4.78**		
Duration of daily computer use (hours)					
- 1-	7	10.0	15	21.4	X^2= 19.98 P= 0.000*
- 3-	50	71.4	40	57.1	
- 5-	10	14.3	13	18.6	
- 7+	3	4.3	2	2.9	
Mean ± SD.	**3.27 ± 1.08**		**4.41 ± 3.65**		
Use eye glasses during computer use					
- No	63	90.0	54	77.1	X^2= 3.213 P=0.632
- Yes	7	10.0	26	22.9	
Use of contact eye lenses during computer use					
- No	70	100.0	67	95.7	X^2= 2.475 P= 0.479
- Yes	0	0.0	3	4.3	

X^2 Chi square test *Statistically significant at ≤ 0.05.

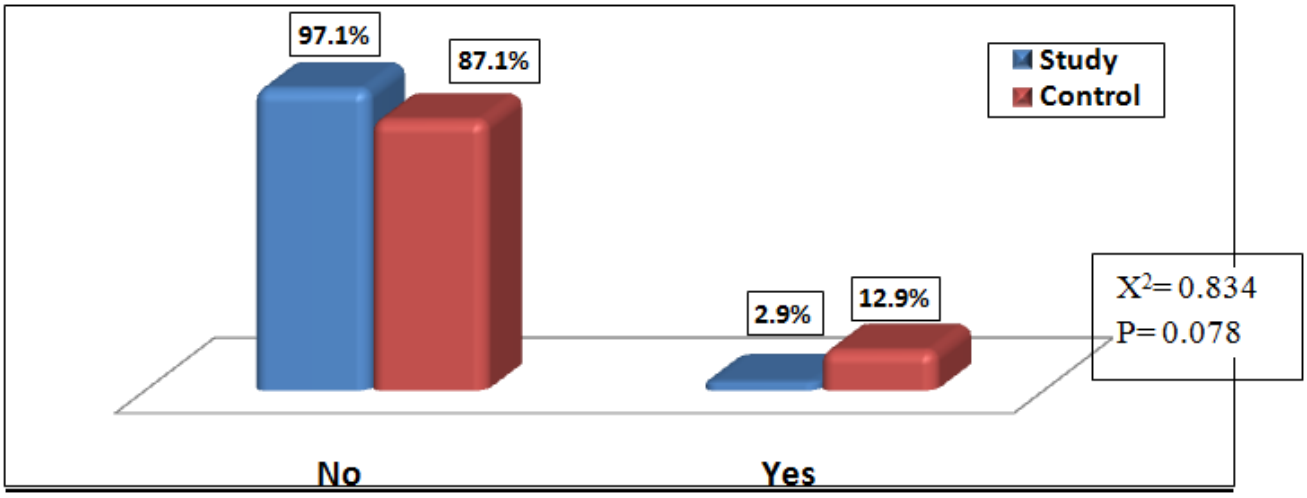

Figure 1. Distribution of the studied employees according to their previous awareness about DES

Table 3. Distribution of the study and control group according to their eye complaints, total knowledge, preventive ergonomic practices and workstation design

Items	Before the educational intervention				One month after the educational intervention				Three months after the educational intervention			
	Study group (n=70)		Control group (n=70)		Study group (n=70)		Control group (n=70)		Study group (n=70)		Control group (n=70)	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total eye complaints												
- Mild	0	0.0	0	0.0	0	0.0	0	0.0	55	78.6	0	0.0
- Moderate	40	57.1	52	74.3	70	100.0	51	72.9	15	21.4	54	77.1
- Severe	30	42.9	18	25.7	0	0.0	19	27.1	0	0.0	16	22.9
Total knowledge level												
- Poor	27	38.6	12	17.2	0	0.0	15	21.5	0	0.0	25	35.7
- Fair	43	61.4	57	81.4	20	28.6	50	71.4	28	40.0	35	50.0
- Good	0	0.0	1	1.4	50	71.4	5	7.1	42	60.0	10	14.3
Total preventive ergonomic Practices												
- Poor	62	88.6	54	77.1	0	0.0	63	90.0	0	0.0	56	80.0
- Fair	5	7.1	15	21.5	20	28.6	7	10.0	13	18.6	9	12.9
- Good	3	4.3	1	1.4	50	71.4	0	0.0	57	81.4	5	7.1
Total workstation design												
- Poor	20	28.6	10	14.3	4	5.7	19	27.2	0	0.0	19	27.2
- Fair	50	71.4	57	81.4	35	50.0	50	71.4	4	5.7	50	71.4
- Good	0	0.0	3	4.3	30	44.3	1	1.4	66	94.3	1	1.4

Table 4. Mean difference between the study and control group according to their total knowledge regarding DES, eye complaints, preventive ergonomic practices and workstation design

Variables	Maximum total allowed score	Before the educational intervention		Test of Sign.	One month after the educational intervention		Test of Sign.	Three months after the educational intervention		Test of Sign.
		Study group (n=70)	**Control group (n=70)**		**Study group (n=70)**	**Control group (n=70)**		**Study group (n=70)**	**Control group (n=70)**	
		Mean ± SD	**Mean ± SD**		**Mean ± SD**	**Mean ± SD**		**Mean ± SD**	**Mean ± SD**	
Total eye complaints score	40	32.59±3.767	31.67±5.620	t=0.604 P=0.079	23.31±1.681	31.24±4.888	t= 17.691 P=0.001*	18.09±1.106	32.35±5.140	t= 25.875 P=0.000*
Total knowledge score	46	28.51±4.376	25.49±4.665	t= 0.993 P=0.062	41.67±1.595	27.93±3.254	t= 31.72 P=0.000*	35.81±2.564	24.73±3.345	t= 18.025 P=0.000*
Total preventive ergonomic practices score	34	8.27±5.214	8.71±4.414	t= 0.294 P=0.588	31.93±1.958	7.961±3.424	t= 50.845 P=0.000*	29.26±5.962	7.49±2.741	t= 29.032 P=0.000*
Total workstation design score	28	18.07±2.162	17.10±4.351	t= 2.798 P=0.097	23.01±5.353	16.60±3.052	t= 14.135 P=0.019*	24.12±5.330	16.60±3.052	t= 14.135 P=0.000*

t independent sample t test * Statistically significant at ≤0.05.

Table 5. Correlation between the study group's total scores of eye complaints, knowledge, preventive ergonomic practices and workstation design before the educational intervention

Items	**Total eye complaints (pre-program)**	
	r	**P**
- Total preventive ergonomic Practices	-0.438	0.000*
- Total workstation characteristics	-0.309	0.000*
- Total knowledge score	- 0.316	0.000*

r Pearson correlation coefficient test * Statistically significant at ≤0.05.

Table 6. Distribution of the study group according to their satisfaction of the interactive-digital based DES educational program

Satisfaction with the interactive-digital based DES educational program	**Study group (n=70)**					
	Neutral		Agree		Strongly agree	
	No.	%	No.	%	No.	%
- Program objectives	5	7.1	28	40.0	37	52.9
- Content	4	5.7	25	35.7	41	58.6
- Content presentation methods	3	4.3	29	41.4	38	54.3
- Usefulness of the program	2	2.9	26	37.1	42	60.0
Total satisfaction score	Dissatisfied		Moderately satisfied		Highly satisfied	
	No.	%	No.	%	No.	%
	0	0.0	20	28.8	50	71.4

5. Discussion

Digital eye strain is a global swift escalating health issue concomitant with advanced technology. Human eyes can maintain focus on the printed materials than computers as it has better contrast and well-demarcated edges. In contrast, computers have ill-defined edges with less contrast which is brighter at the center and decreased in intensity toward edges. This can result in ocular muscle strain to maintain focus and can lead to several eye complaints with prolonged computer use which can be prevented through proper ergonomic practices and properly designed computers' workstation [20,22].

The present study depicts that DES is a widespread problem among computer users in Damanhour University. Before the educational intervention, the entire study and control group had either moderate (57.1%, 74.3%) or severe (42.9%, 25.7%) eye complaints, respectively. This could be explained by the prevalent improper ergonomic practices and workstation design as well as the poor DES knowledge among most of the studied computer users before the educational intervention either in the study and the control group. In addition to, the young age of both the study (27.03±6.80) and control (27.86±9.32) groups, also the majority of both the study (97.1%) and control (87.1%) groups has no erstwhile awareness about DES. In accordance, Chauhan S (2018) [24] portrayed a prevalent poor awareness about DES and ergonomics among their studied computer users which was found to be significantly associated with the participants' age where most of them were young with a nearly similar mean age (25.98 ± 4.61) to the current study. This younger age is the active period of one's life with its associated multiple roles' responsibilities that can force the person to work in multiple occupations. Consequently, the working duration on a computer can be increased which further can increase the severity of eye complaints.

The raised prevalence of DES among computer users was reinforced by three recent studies. First, an Egyptian study by Iqbal M et al (2018) [18] implied that 86.0% of

their studied sample had complained from DES manifestations where the dry eye, blurred vision and headache were the utmost shared symptoms. Second, Assefa N et al (2017) [19] revealed that about three quarters of their studied computer users suffered from DES where the most experienced manifestations were blurred vision, headache and eye redness. Third, Agarwal S et al (2013) [22] showed that most of their studied computer users reported ocular complaints as eyestrain, itching and burning sensation. All those confirmatory studies highlighted that poor ergonomic practices and workstation design were significant contributors to DES.

Evidently, the current study implied a significant negative correlation with the total reported eye complaints and the studied computer users' preventive ergonomic practices and workstation design. Such correlations were supported by several novel studies. First, Iqbal M et al (2018) [18] clarified that DES symptoms were correlated with the long time spent on computers (≥3 hours). Congruently, the existing study displayed that utilizing a computer for 3<5 hours per day was portrayed among most of both the study (71.4%) and control (57.1%) groups with a statistically significant difference. Second, Khatri A and Kharel R (2018) [25] portrayed significant reduction in eye symptoms by taking rest breaks, frequent blinking and lower computer screen level during computer use. Third, Lizette M et al (2017) [13] portrayed a significant negative correlation between symptoms of DES and ergonomic practices as viewing angle and monitor level in relation to eyes.

Furthermore, Assefa N et al (2017) [19], Ranasinghe P et al (2016) [3] and Jomoah I (2014) [26] found that poorly designed workstations were associated with high prevalence of eye symptoms among their studied computer users especially, poor lightening, unavailability of height-adjusted chairs and antiglare screen. Conversely, Gabal M et al (2011) [27] revealed no significant association between DES and workstation ergonomic defects. This could be attributed to a lack of assessing the optical history of the studied group who may have ocular etiologies or abnormalities that may affect the result in this contradictory study. In contrast to this, the current study found that most of both the study and control groups had neither health problems (75.7%, 78.6% respectively) nor history of eye problems (80.0%, 91.4% respectively).

The current study also portrayed a significant negative correlation between total reported eye complaints and the total knowledge score of the studied computer users. Similar findings were revealed by two recent studies. First, Ranasinghe P et al (2016) [3] found that knowledge about DES and ergonomic practices was significantly associated with the presence of eye symptoms among their studied computer users. Second, Dessie A et al (2018) [12] conferred that knowledge was a significant predictor of DES where computer users who had good knowledge about safety measures for computer use had less frequent eye symptoms. This highlights the pressing need for developing educational intervention about DES and its preventive ergonomic practices which in turn can enhance work accuracy and productivity.

The World health organization (WHO) in 2019, has endorsed the necessity of employing digital health as a main advanced route for information and communication technology to meet health needs which further can aid in health system consolidation and amelioration of customers' satisfaction. It recommends the provision of digital health education and training content to enhance access for health information and services [14,15]. Therefore, an Interactive Digital-Based DES educational intervention by using e-mail and WhatsApp was developed and implemented by the researchers to present the program content to be easily reachable at any time for the studied computer users for better education about DES and its preventive ergonomic practices.

The results of the current study highlighted the effectiveness of the current interactive digital-based educational intervention about DES on reducing the severity of eye complaints among the studied computer users. A statistically significant negative mean change in the total score of the reported eye complaints was observed among the study than the control group, one month and three months next to the educational intervention. This could be ascribed to the fitting designation and presentation of the program content which might has a great role in enhancing computer users' knowledge and compliance with the preventive ergonomic practices which by their role can assist in reducing the severity of their eye complaints.

Consistent findings were shown by four recent evidences. *First,* Lertwisuttipaiboon S et al (2017) [28] revealed that the proportion of eye strain was significantly decreased among the intervention group one month and two months after program implementation. *Second* Konarska M et al (2015) [29] portrayed that their ergonomic intervention was associated with improvement in the visual strain among their studied computer users. *Third,* Gupta R et al (2014) [30] publicized that their three months intervention using of health education, eye exercises and workstation design was effective in reducing asthenopic complaints among their studied computer workers. *Fourth,* Amick B et al (2012) [31] proved that ergonomic training significantly decreases the severity of visual symptoms among the studied office workers after the educational intervention and this effect was sustained throughout one year.

Deficient awareness and knowledge about DES and proper ergonomic practices can contribute o myriad of eye problems. [32] The results of the current study pinpoint the significance of interactive digital-based educational intervention program about DES in enhancing the studied computer users' knowledge about DES as regards its definition, causes, manifestations and preventive ergonomic practices. The existing study revealed that the entire study group had either fair (61.4%) or poor (38.6%) knowledge level before the educational intervention which increased to good knowledge level one month (71.4%) and three months (60.0%) after the educational intervention. However, the control group had fair knowledge level across all study phases (81.4%, 71.4%, 50.0% respectively). A positive mean change in the overall knowledge score was displayed among the study group with a statistically significant difference between both groups after the program implementation. This could be ascribed to the efficacious designation of the current educational intervention and the young age of the studied computer users, where the highest percent of them aged between 20<30 years and

had university educational level. This can aid in better knowledge synthesis and retention. Considerably evidence showed that knowledge is the meaningful outcome of a cognitive psychological process encompassing the interaction between logic and meaningful ideas, relevant background, ideas in the leaner's cognitive structure and mental set for meaningful learning and knowledge acquisition and retention [33].

Similar improvement in knowledge score was reported by Menaria K et al (2018) [32], Alex K (2015) [34] and Sam SH and George R (2015) [35] who found a significant increase in the mean knowledge score of their studied computer users after application of their instructional module where most of their participants had inadequate knowledge about DES and its prevention prior to the educational intervention which significantly changed to adequate knowledge level in post-test. Furthermore, those confirmatory studies showed that most of their participants also were in the age group from 20 to 30 years and had higher educational level. Otherwise, Upadhyaya A and Joshi R (2014) [36] showed no significant association between total knowledge of their studied computer users' age and educational attainment. This could be attributed to the homogeneity of the studied sample in this contradictory study where all of them were adolescent school students and aged between 15-18 years.

The American Optometric Association (AOA) recommended numerous ergonomic practices for reducing DES; setting the computer screen below eye level by 15- 20 degrees from the screen center; avoid glare on the screen through using curtains and lower wattage bulbs; locating reference materials above the keyboard and below the screen monitor or proper use of document holder; taking rest break (15 minutes) after two hours of unremitting computer use or distance looking for 20 seconds every 20 minutes of computer work and blink frequently to avoid eye dryness or performing 20-20-20-rule [5,7].

The existing study proved the significance of the interactive digital-based educational intervention program about DES on improving the studied computer users' ergonomic practices. It elaborated that most of the study group had poor (88.6%) total preventive ergonomic practices before the educational intervention which elevated to good level one month (71.4%) and three months (81.4%) after the educational intervention. However, the control group had poor total preventive ergonomic practices across all study phases (77.1%, 90.0%, 80.0% respectively). The total preventive ergonomic practices score showed positive mean change among the study group at one and three months after the educational intervention with a statistically significant difference between the two groups. Specifically, this significant positive mean score change was revealed in all computer users' preventive ergonomic practices including the location of a computer screen and reference materials, taking rest breaks during work, monitor display settings, lighting, seating position, use of antiglare screen and practice of eye blinking.

Notwithstanding the evident relationship between visual symptoms and computer usage, rare interventional studies about the ergonomic practices were existent. Concurred findings were shown in three novel studies. First, Lertwisuttipaiboon S et al (2017) [28] revealed that the mean practice score of the study group before the intervention was at the level of poor practice however it was increased to the level of fair practice one moth and two months after program implementation. Second, Hussein N (2012) [37] showed a significant mean change in the studied computer users' ergonomic practices related to posture, chair, use of document holder and screen adjustment next to the educational intervention. Third, Poonguzhali S et al (2015) [38] concluded that their applied ergonomic training intervention was effective in decreasing the experienced physical discomfort among their studied computer users.

An appropriately designed workstation can service in reducing DES. AOA recommended several environmental workstation characteristics for decreasing DES as availability of height-adjusted chairs, feet rest, antiglare screen and document holder beside the screen. In addition, proper lighting through using lower wattage bulbs and avoid placing the light source or window in front of the screen to avoid glare reflection [3,5,19,26].

The existing study proved the significance of the interactive digital-based educational intervention program about DES in helping the studied computer users to modify their workstation design. It portrayed that the entire study group had either fair (71.4%) or poor (28.6%) total score of workstation design which increased after one month to fair (50.0%) level whereas after three months of the educational intervention most of them increased to a good level (94.3%). Conversely, the control group had fair total workstation design throughout all the study phases (81.4%, 71.4%, 71.4% respectively). A positive change in the mean score of the total workstation design was found among the study group at one and three months after the educational intervention with a statistically significant variance between both groups. Specifically, a significant mean score change was revealed in all workstation characteristics which included the location of a computer screen, proper lighting, availability of height-adjusted desk and chairs, presence of antiglare screen and document holder. It is worth mention that, the limitation of the workstation design was mainly found to be due to administrative resistance and unavailability of the needed facilities. The same was confirmed by Ranasinghe P et al (2016) [3] who reported that the most common reasons for poorly designed computer workstations were deficient facilities and unbelieving on their influence on eye symptoms.

Consistent findings were portrayed by two recent studies. First, Konarska M et al (2015) [29] found that their studied computer users had improper working conditions including poor lighting, unfitting chairs without wrist support and high viewing angle. The study proved significant improvement in workstation design after the intervention mainly in chair, lighting and sitting posture. Second, Ketola R et al (2012) [39] proved a significant positive mean change in the workstation ergonomics score at two and ten months next to the educational program which mainly included amendments of the screen, forearm supports, mouse, keyboard, and chair.

Despite the advances of the digital health intervention on improving several health outcomes and behavior change, yet a plentiful deal is needed to be learned about customers' satisfaction with such electronic delivery approaches. The existing study illustrated that nearly three

quarters (71.4%) of the study group was highly satisfied with the interactive digital-based DES educational intervention. The highest percent of the studied computer users was strongly agreed with the program objectives (52.9%), content (58.6%), content presentation methods (54.3%) and usefulness of the program (60.0%). Specifically, they reflected that the interactive digital-based educational intervention was complete, comprehensive and had up to date knowledge where its educational objectives were clear and meet participants' needs and expectations. In addition, its content was simple and easily understandable.

Compatible results were illustrated by three novel studies. First, A recent systematic review evaluating the efficacy of digital education on enhancing the healthcare professionals' adoption of the clinical guideline by Car L et al (2019) [23] described that most of the incorporated satisfaction studies underlined that the digital educational intervention was preferential than traditional learning. Second, Hussein N (2012) [37] conducted a study to evaluate the impact of guideline application on the prevention of occupational overuse syndrome. It elaborated that the majority of the studied computer users were satisfied by the educational program where they reported that using guideline on compact disc was informative, applicable, easily understandable, easy to use and useful in preventing computer associated discomfort. Third, Maierle D and Ryan P (2011) [40] evaluate the utilization and satisfaction with electronic intervention for health behavior change. The study indicated that most of their respondents were either very or extremely satisfied with the electronic intervention using both Web site and computer.

6. Conclusion

Based on the existent study findings, it can be concluded that the three-research hypothesises are accepted and the interactive digital-based educational intervention about DES and its preventive ergonomic practices is effective in decreasing severity of reported eye complaints, improving their knowledge level about DES and modifying their preventive ergonomic practices and workstation design. Evidently, most of the study group was highly satisfied with the interactive digital-based DES educational intervention.

7. Recommendations

Based on the present study's findings, it is recommended to: -

- Developing an ergonomic training program as part of the initial training program of all computer users' employees.
- Enforcing regular and periodic eye examination of computer users with well-established reporting system.
- Developing hotline and web-based educational sites about visual ergonomics for digital users to facilitate interaction and communication
- Utilizing digital health education to disseminate evidence-based information about DES and its preventive ergonomic practices
- Establishing awareness campaigns about DES and its preventive ergonomic practices.

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