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Risk factors of digital eye strain among computer users at Al-Baha University

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Background: Digital eye strain (DES) affects an estimated 60 million people worldwide, with a higher prevalence among populations that are occupationally reliant on digital display devices.

Aim: This study investigated risk factors of DES and ergonomic practices among computer users at Al-Baha University.

Setting: The study was conducted among computer users at Al-Baha University.

Methods: This study used a descriptive cross-sectional design and data were gathered using self-administered questionnaires.

Results: A total of 360 computer users participated (mean age: 36.33 years, standard deviation [s.d.]: 7.08). The lifetime and daily computer usage were 8.38 (s.d.: = 1.04) years and 4.37 (s.d.: = 2.07) hours, respectively, with 30% of respondents having used computers for more than 10 years. The baseline total eye complaints score was either mild or moderate for 64.7% and severe for 35% of the sample. The total workstation design score was poor for 47.1% and fair for 35.5% of the sample. The regression analysis of potential DES risk factors found statistically significant coefficients for the duration of daily computer use, use of contact lenses, poor ergonomic practices, poor workstation design and use of non-prescription spectacles.

Conclusion: This study emphasises the need for learning institutions and public health policy makers to not only raise awareness about digital eye strain but also impose time restrictions and breaks on digital-based activities and generally improve workstation design and ergonomic conditions.

Contribution: This study offers a basis for targeted interventions to prevent and manage DES, particularly within learning settings.

Keywords: digital eye strain (DES); ergonomic practices; computer users; occupation; computer vision syndrome.

Introduction

The use of visual display terminals has become a necessity in 21st century work, education, and private lives, after barely three decades of the personal computer and computing devices revolution. While office work involves a range of disparate and adequately varied mental, physical, and social activities (e.g., writing, typing, in-person meetings, and filing), computers combine many activities. This enhances efficiency, productivity, and quality.[1] The impact of computing devices on personal and social lives, including leisure and communication has similarly been disruptive. These many benefits did, however, come at an increasingly steep price that continues to manifest in diverse forms.[2] These include health problems that flow from the routine and prolonged use of personal computers and digital screens, such as occupational overuse syndrome (OOS), migraine, psychosocial tension, and digital eye strain (DES).[3,4]

Digital eye strain or computer vision syndrome (CVS) refers to many eye and vision-related problems, as well as external and internal symptoms, resulting from prolonged usage of computers, tablets, e-readers, smartphones, and other high-resolution digital displays.[1,5] External symptoms include irritation, burning sensation, discomfort, tearing, and dryness besides neck and shoulders pain, while internal symptoms include strain, ache, and a headache behind the eyes.[2,4,6,7] Digital eye strain is a rising epidemic confronting the world as a negative unintended consequence of improper use of technological advancements. Digital eye strain can contribute to the reduction of employees' quality of life and work accurateness, which may diminish work productivity.[2,8,9]

Past research has targeted occupations that involve extensive use of computers and high-resolution digital or video display terminals, including radiation levels and prevalence among different population groups.[8,10,11] These include teleworkers, office workers, radiologists, academic staff, and students in virtual classes.[2,12] Multiple internal and external risk factors may similarly be responsible for the occurrence and progression of DES. Internal risk factors are chiefly related to the existence of untreated pre-existing eye problems, such as astigmatism, ametropic or refractive errors such as far or nearsightedness, and poor accommodation.[8,13,14] On the other hand, risk factors for external symptoms of DES mainly flow from poor ergonomic practices, including workstation situation, uncomfortable position, prolonged viewing of digital screens, improper lighting conditions, uncommon blinking, glare, and incorrect distances between the eye and the device. Recent studies showed high prevalence of DES, unsatisfactory knowledge about DES and poor preventive ergonomic practices.[5,13] Tesfaye et al.[2], Assefa et al.[10] and Tafese et al.[15] show that the prevalence of musculoskeletal conditions, which constitute about 2% of the global disease burden, increased by 25% over the last decade. This is, in part, because of a lack of awareness of the anatomical and physiological demands of computer use as well as other sedentary work, learning, and leisure activities. The majority of these studies primarily targeted populations in Europe and North America, where demographic and device usership behaviours may vary significantly from those in Africa and the Middle East.[8,10]

Predictably, public health concerns of DES are increasingly becoming a problem for researchers and policy makers. Digital eye strain is one of the commonest occupational hazards, with an estimated 60 million people globally, suffering from it.[4,5] As many as 45 million workers across the world spend at least several uninterrupted hours looking at digital display screens. In Saudi Arabia, Turkistani et al.[16] estimated that 77% suffer from DES, with the most prevalent symptoms being eye-burning, itching, blurred vision, tearing, headaches, back pain, neck pain, and shoulder pain. The prevalence rates are even higher among occupationally predisposed population segments, including students.[7] This is why it is critical to study eye strain prevalence as well as risk factors, as a basis for devising strategies to mitigate its effects on the most at-risk populations.[17]

Multiple studies have since tried to identify risk factors among specific occupational groups (e.g. radiologists, students, and teleworkers) using diverse methodologies,[5,17,18] but much remains unknown on account of the broadly different occupational, individual, group, institutional, and time-variant exposures that face equally diverse segments of the population. The prevalence of DES among computer users varies but can reach up to 90%.[5,18] Studies elsewhere, including Ethiopia and Nigeria show that as many as 40% of computer users experience symptoms of DES, with 73% of occupationally exposed persons such as secretaries, bankers, and data processors exhibiting symptoms of DES.[11]

Mowatt et al.[7] studied eye symptoms among undergraduate college students and portrayed a significant negative correlation between symptoms of DES and ergonomic practices. Many of the extant studies focus on the frequency and risk factors of DES such as improper workstation design and prolonged computer use, but primarily focus on adult subjects in the West. Consequently, there remains a dearth of data on DES risk factors and prevalence in sub-Saharan Africa and the Middle East, including Saudi Arabia. This study further serves to inform the need for action towards combatting the problem, by investigating the risk factors of DES (including computer workstation ergonomics) among computer users at Al-Baha University and estimates the effect of the identified risk factors on DES symptoms.

Methods

Research design and sampling

This study used an observation analytical study design involving cross-sectional sampling. The study population comprised students and employees at Al-Baha University, Saudi Arabia. Established in 2006 in the southern region of the kingdom, Al-Baha University has an estimated student population of 21 000 (Al-Baha University, 2022). The study was undertaken at both the male and female wings of the university's administrative buildings. All individuals who were willing to participate and met the inclusion criteria, that is, continual computer use for at least 2 years, and absence of severe pre-existing eye disorders, were included in the study. The sample size was estimated by way of Cochran's formula (using the EPI Info 7 software) and respondents were selected by simple random sampling. Using the Taro Yomane formula, assuming a 50% predictive prevalence and a 5% margin of error, the minimum adequate sample size was estimated at 374, $p < 0.05$.

Tools for data collection

This study relied on two tools: Computer User's Structured Questionnaire Sheet (CUSQS) and the Ergonomic Practices and Workstation Design Observational Checklist (EPWDOC). The CUSQS tool was custom-developed by researchers from the recent literature. It comprised two parts. The first part sought demographic and computer usage data. The demographic data included age, gender, and educational level. The tool similarly gathered medical history data, including comorbidities, eye problem history and history of eye surgery as well as any history of past ophthalmological consultation for eye problems and related medication use. The computer use data included the lifetime duration of computer use (years), daily computer use (hours), and use of spectacles or lenses during computer use.

The second part of the CUSQS tool was an Assessment of Self-Reported Eye Complaints adapted from Arif and Alam.[19] It has 20 self-reported items comprising 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, and (2) frequently. The total score was calculated and ranged from 0 to 40. The total score was graded on a three-point ordinal scale: mild (0 < 20), moderate (20 < 30), and severe (≥ 30).

The EPWDOC tool was adapted from the American Optometric Association's recommended guidelines for the prevention of DES. It comprised two parts. The first part comprised 17 constructs that sought to capture data on the computer users' preventive ergonomic practices. The 17 items are categorised into eight dimensions: location of the 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 a three-point Likert scale: (2) accurately done, (1) inaccurately done, and (0) not done. The resulting total score scale was a 34-point ordinal scale, which was further graded on a three-point ordinal scale: poor practice (0 < 17), fair practice (18 < 26), and good practice (> 26).[10]

The second part of the EPWDOC tool assessed elements of workstation design. The scale comprised 14 items, that are categorised into six dimensions as follows: computer screen (4), anti-glare screen (1), lighting (3), document holder (3), desk (1) and chair (2). Each item was scored using a three-point categorical scale: (2) if present, (1) if absent, and (0) if not applicable. The total observational score was calculated, ranging between 0 and 28. It was subsequently graded using a three-point ordinal scale: poor workstation (0 < 14), fair workstation (14 < 21), and good workstation (≥ 21).[19,20]

Procedures

The data collection tools were developed by the researchers after a thorough review of relevant recent literature, before being piloted using a jury of three experts in the field of ophthalmology to ascertain the construct validity. To ascertain the clarity, applicability, and feasibility of the tools, as well as to detect potential obstacles that might impede the data collection process, the tools were piloted using 20 computer users that were subsequently excluded from the sampling frame. The Cronbach's alpha coefficient showed that the scales were highly reliable (66 items: $\alpha = 0.81$). The data were collected from August 2021 to October 2021. The descriptive and inferential statistics were obtained by using Microsoft Excel and IBM® SPSS® 21 software packages.

Ethical considerations

Ethical approval was obtained from the Institutional Review Board of Al Baha University (No. 1443-21-43110072).

Results and discussion

Demographic attributes

A total of 380 computer users (69.2% female) completed the survey. The mean age of the respondents was 36.33 (standard deviation [s.d.]: 7.08) years and at least 76% were university graduates, while 23% had a high school qualification. Three-quarters (75.3%) of the respondents believed that their monthly income was enough. Concerning DES symptoms, 79.2% of respondents believed they did not have any problems before using digital devices, while 20.8% self-reported suffering from eye problems before using digital devices. Up to 55.8% of the respondents had never consulted an ophthalmologist, optometrist or optician and only 4.5% had undergone surgery. At least 16% took medications for eye conditions. Table 1 shows the demographic characteristics of the participants.

Computer use characteristics

On an average, the respondents reported active usage of digital computing devices 8.38 (s.d.: 1.04) years during their lifetimes and 4.37 (s.d.: 2.07) hours daily. At least 30% of the sample had used computers for more than 10 years, 25% of whom used computers for more than 5 h per day. Only 32.1% and 4.5% reported using spectacles and contact lenses, respectively, when using computers. Table 2 shows the computer usage characteristics of the participants.

The average of 4.37 h of daily screen time is consistent with the generally high screen time among students and

TABLE 1: Demographic characteristics.

Participant characteristics	Study sample (*N* = 360)			
	n	%	Range	Mean ± s.d.
Personal characteristics and medical history			20–56	36.33 ± 7.08
Age (years)				
20–29	152	40.0		
30–39	112	29.5		
40–49	80	21.1		
Above 50	36	9.5		
		36.0		
Gender				
Male	117	30.8		
Female	263	69.2		
Level of education				
University education or above	289	76.1		
Secondary education or less	91	23.9		
Monthly income				
Not enough	78	20.5		
Enough	286	75.3		
Enough and save	16	4.2		
History of eye problem				
No	301	79.2		
Yes	79	20.8		
Previous ophthalmologist, optometrist, or optician consultation				
No	212	55.8		
Yes	168	44.2		
Previous eye surgery				
No	363	95.5		
Yes	17	4.5		
Medications use				
No	316	83.2		
Yes	64	16.8		

TABLE 2: Distribution of the studied computer users according to their computer usage characteristics.

Items	Study sample (N = 360)		
	n	%	Mean ± s.d.
Duration of computer use (years)			8.38 ± 1.04
Less than 5	85	22.4	
5–9	181	47.6	
10–14	76	21.1	
More than 15	38	10.5	
Duration of daily computer use (h)			
1–2	63	16.6	4.37 ± 2.07
3–4	219	57.6	
5–6	62	16.3	
7 or more	36	9.5	
Do you use spectacles during computer use?			
No	258	67.9	
Yes	122	32.1	
Do you use contact eye lenses during computer use?			
No	363	95.5	
Yes	17	4.5	

younger people during the COVID-19 pandemic.[6,21] Assefa et al.[10] found that using computers for 20 minutes without breaking doubled the odds of DES while doing so while wearing spectacles only increased the odds marginally. Other studies found that DES is inversely correlated with age on account of the higher screen time. More screen time has similarly been strongly linked with a higher prevalence during the COVID-19 pandemic.[6,21,22] This is relevant because this study was conducted after the pandemic, thus the screen time and prevalence of DES may be linked to the pandemic's increased leisure time and working and/or learning from home.[23] Notably, only 36% of those sampled in this study wear either spectacles or contact lenses while using computers. Sheppard and Wolffsohn[24] and Yammouni and Evans[25] show that contact lenses and light-filtering spectacles potentially help to mitigate DES symptoms. Other studies, including Markoulli et al.[26] and Wróbel-Dudzińska et al.[14] found that spectacles- and contact lens-related problems resulting in stress, lower wearing time, conjunctiva staining, more chair time, and ultimate discontinuation heighten the risk of DES. Similarly, taking frequent breaks and using dry eye or tear supplements reduce the odds by 0.3 and 0.55, respectively.[2]

Workstation design and ergonomics

The majority of the sampled population's baseline total eye complaints score was either mild or moderate (64.7%). At least 35% had a severe total eye complaint score. The self-reported baseline preventive ergonomic practices score was poor among 66.3% of the sampled computer users, with only 15.3% a good baseline score. Similarly, the total workstation design score was found to be poor for 47.1% and fair for 35.5% of the sample (Figure 1).

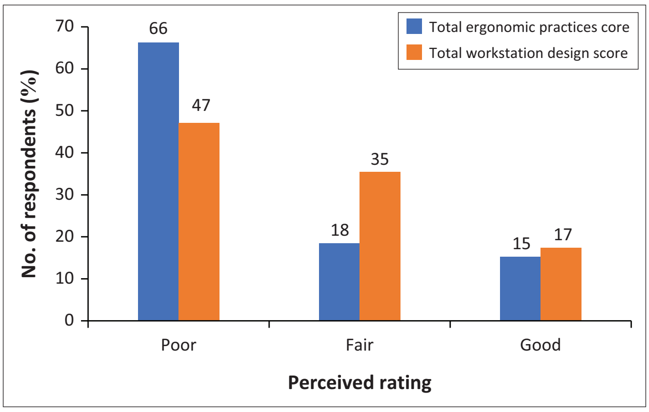

FIGURE 1: Ergonomic and workstation design scores.

The finding of moderate or mild baseline complaint score could explain the equally poor instrumental preventive behaviours among 66.3% of the sample as many people would not see the need to mitigate a condition that is not severe.[23,26] Contrarily, however, the finding of a negative and statistically significant coefficient between the total eye complaints with both the total preventive ergonomic practices and total workstation design shows that these interventions are acceptably effective. This finding shows that even people who have severe DES symptoms do not engage in preventive or mitigative practices. More research is, however, required to establish the causal reasons for the lack of instrumental preventive behaviours as well as the motivations for the people who engage in good preventive practices.

The Pearson rank correlation analysis results show that the coefficient of total eye complaints scores of the studied computer users, with both the total preventive ergonomic practices and total workstation design, is negative and statistically significant, $p < 0.05$ (Table 3).

The large gap between the proportion of respondents who felt they did not have pre-existing DES symptoms and the 20.8% who self-reported pre-existing conditions points to one possible conclusion. It is possible that DES prevalence is low in either the sample or the Al-Baha University population, but given the high prevalence rate of DES in the general population and students,[5,7,16] it is more likely that the awareness of either the condition or its symptoms at Al-Baha University is low. The fact that the vast majority of the respondents had never consulted an ophthalmologist, optometrist or optician for DES or any other problem, and further that the proportion of those who had is broadly consistent with the 20%, 4.5%, and 16% who self-reported suffering from eye conditions, having had surgery, and taking medications, respectively, bolsters the lack of awareness finding.

Digital eye strain risk factors and their effects on digital eye strain

The univariate linear regression model for predictors of DES among computer users showed that the coefficients of the duration of daily computer use, use of contact lenses while working on a digital device, and using properly indicated spectacles or lenses to working on a computer, were statistically significant at 5%. In addition, preventive ergonomic practices and workstation design showed a significant relation to the DES among studied computer users (Table 4).

This study shows the existence of potentially positive causal relationships between the duration of daily computer use (hours), use of contact lenses, poor ergonomic practices, use of spectacles or lenses not specified for working on a computer, and poor workstation design. The findings concerning the duration of computer use are consistent with past studies on the increased screen time among at-risk populations such as students, radiologists, and office workers.[4,8,13,21] Basnet et al.[27] , Mowatt et al.[7], Ganne et al.[21], and Tesfaye et al.[2], for example, found that the prevalence of DES among students and academic staff was between 50% and 74%, compared with about 33% for the general population, while Ranasinghe et al.[4], Portello et al.[8] and Salinas-Toro et al.[28] also found that the prevalence is higher among office workers than the general population.

On their part, Abudawood, Ashi, and Almarzouki[23] did not find a statistically significant relationship between wearing contact lenses or spectacles and DES, even though, unlike this study, they did not test whether the spectales and/or lenses were indicated for working with computers. Concerning visual ergonomics, poor posture, and workstation design, there is a consensus in the majority of the available empirical literature that is consistent with this study's finding on the same, on their causal linkage with DES as well as musculoskeletal pain and fatigue.[3,5,7,12,13,28] This appears to be the case across diverse methodological operationalisations of the same variables. Sheppard and Wolffsohn[24], Ganne et al.[21], Boadi-Kusi et al.[12], and Tesfaye et al.[2], for example, found that improper illumination levels, use of visual display terminals, maintaining screen distances of less than 20 cm, and using computers for more than 9 years had statistically significant odds of causing DES.

TABLE 3: Correlation between the study group's total scores of eye complaints, preventive ergonomic practices, and workstation design.

Items	Total eye complaints	
	r	*p*
Total preventive ergonomic practices	-0.165*	0.001
Total workstation design	-0.117*	0.022

*, Statistically significant at ≤ 0.05.

TABLE 4: Univariate linear regression model for predictors of digital eye strain among computer users (N = 380).

Computer user-related factors	Standardised coefficient (Beta)	t-stat.	*p*	95% CI	
				Lower limit	Upper limit
Age	0.071	1.388	0.166	-0.032	0.188
Gender	-0.074	1.448	0.149	-2.932	0.445
Level of education	-0.048	0.938	0.349	-1.932	0.684
Monthly income	-0.006	0.114	0.909	-1.760	1.567
Presence of health problems	0.033	0.648	0.517	-0.711	1.410
History of eye problem	-0.008	0.156	0.876	-2.079	1.773
Medications use	-0.044	0.862	0.389	-3.002	1.172
Duration of computer use (years)	0.039	0.756	0.450	-0.465	1.045
Previous ophthalmologist, optometrist, or optician consultation	-0.072	1.404	0.161	-2.691	0.449
Duration of daily computer use (hours)	0.107	2.083*	0.038*	-0.774	-0.022
Use of spectacles	-0.058	1.131	0.259	-2.633	0.710
Use of contact lenses	0.162	3.198*	0.002*	2.337	9.799
Spectacles or lenses are specified for working on a computer	0.115	2.253*	0.025*	-6.088	-0.414
Practice	0.165	3.250*	0.001*	0.078	0.318
Workstation design	0.117	2.295*	0.022*	0.040	0.517

t-stat., t-statistic; 95% CI, 95% confidence interval.
*, Significant at $p < 0.05$.

Demographic characteristics, including age, gender, income, education level, health problems, history of eye problems, and use of medications are not statistically significant determinants of DES. These findings are inconsistent with the previous studies that linked DES to heightened digital device utilisation among certain demographic groups. These include findings of an inverse relationship between DES and age (mediated by screen time),[6,21] and a slightly higher DES prevalence among females.[5,17,23,29] Individuals in occupations that require high computer use, including students in virtual classes, radiologists, and telemarketers were particularly exposed during the COVID-19 pandemic.[6,7,8,12,17]

Contrary to this study's findings, the past research also links DES to pre-existent eye conditions, use of spectacles, and use of medications.[21,23,30] Other studies linked DES to age,[10] work duration,[5] and duration of working in professions that intensively utilise computers,[2,10,31] and poor posture and visual ergonomics.[5,10] Other than measurement errors, sampling, and demographic differences, the reasons for the divergencies in this study could include the possibility that the pre-existing conditions in this study were not as severe and the medications/classes' effectiveness differ.

Conclusion and recommendations

This study sought to identify the risk factors of DES (including workstation ergonomics) and estimated the effect of the identified risk factors on DES symptoms among computer users at Al-Baha University. The findings reveal that more than 83% of the respondents use digital computing devices for more than 3 h with less than 36.6% of the respondents using spectacles or lenses. Even so, only a minority have optimal workstation design and preventive ergonomic practices. Proper visual ergonomics have been shown to be effective in preventing the development of DES and mitigating the severity of DES.[5,9]

This study similarly bears out the importance of healthy computer use behaviours.[5,9] The inferential analysis shows that the coefficients of the duration of daily computer use (hours), use of contact eye lenses while working on a digital device, and using properly indicated spectacles or lenses while working on a computer, were statistically significant. Preventive ergonomic practices and workstation design have a significant relation to the DES among studied computer users. Recommended behavioural changes include proper screen brightness levels, frequent screen cleaning, proper illumination, and the use of eye drops.[5,27] It is imperative for learning institutions and public health agencies to mount campaigns to increase the awareness of DES, its prevention, and management. Learning institutions (and lecturers) should similarly observe the 20-20-20 rule concerning the length of time for online lessons/activities to less than 4 h, mandate breaks, and ensure ergonomic conditions.[2,32]

The use of spectacles; previous consultations with ophthalmologists, optometrists and opticians; duration of computer use (years); medications use; history of comorbid ocular complaints; general comorbid health conditions; monthly income; level of education, age, and gender do not have a statistically significant effect on the development of DES. While more research is needed to confirm these findings, the evidence from this study helps to achieve more targeted interventions in preventing and managing DES, particularly among learning settings.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Author's contributions

S.K.A.-A. testifies that she conceived, designed and conducted the research, collected and analysed the data, drafted and critically reviewed and approved the final draft of the manuscript. She is responsible for all aspects of the work.

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Data availability

Data supporting the findings of this study are available from the corresponding author, S.K.A.-A., upon request.

Disclaimer

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