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Association Between Digital Eye Strain and Academic Performance Among Clinical-Year Medical Students at the University of Bahri, Khartoum State, Sudan, 2025.

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Abstract

Digital eye strain (DES) is a common occupational and academic concern among clinical-year medical students due to prolonged screen exposure during learning and clinical training. Symptoms, including eyestrain, eye dryness, headaches, and musculoskeletal discomfort, can compromise students' academic performance and overall well-being. Assessing DES prevalence, associated behavioral and ergonomic factors, and its impact on academic outcomes is critical for informing preventive strategies.

Methodology: A cross-sectional study was conducted among 272 clinical-year medical students at the University of Bahri. Data were collected using a validated electronic questionnaire evaluating DES symptoms, visual hygiene practices (including screen duration, breaks, posture, and lighting conditions), and self-reported academic performance (measured via GPA). The sample included students from all three clinical

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years, ensuring representativeness.

Results: The most frequently reported symptoms were eyestrain (64.3%), eye dryness (51.1%), headaches (49.3%), and neck, shoulder, and back pain (41.5%). Prolonged screen

Use, poor posture, and limited adherence to visual hygiene practices, such as the 20-20-20

The Rule was significantly associated with increased DES severity. Higher symptom severity was associated with lower GPA, indicating a clear impact on academic performance. These findings directly address the study's objectives regarding symptom prevalence, contributing factors, and educational consequences.

Conclusion: DES is highly prevalent among clinical-year medical students and is influenced by modifiable behavioral and ergonomic factors. The observed association between symptom severity and academic outcomes underscores the need for structured interventions, including visual hygiene programs, ergonomic adjustments, and the incorporation of DES education into the medical curriculum. Future studies should investigate the long-term consequences of DES and evaluate the effectiveness of preventive strategies to enhance student health and learning outcomes.

Keywords: Digital eye strain, clinical-year medical students, visual hygiene, screen time, academic performance

Introduction

Background

Digital Eye Strain, also known as Computer Vision Syndrome, comprises visual, ocular-surface, and musculoskeletal symptoms arising from prolonged use of digital devices such as computers, tablets, and smartphones [1], [2], [3]. Typical complaints include eye fatigue, dry or irritated eyes, blurred vision, headaches, and difficulty focusing, often precipitated by extended near work, reduced blink rate, suboptimal ergonomics, and intensive screen exposure [2], [4], [5].

Following the COVID-19-related transition to online learning, reliance on screens surged in higher education, intensifying DES as a public-health concern, particularly among university and medical students who depend heavily on digital platforms for lectures, research, clinical documentation, and electronic records [6], [7], [8], [9], [10]. Reported DES prevalence in student populations is high, with multiple studies documenting substantial symptom burdens and links to sleep disruption and fatigue [3], [11], [12], [13]. In Sudan, emerging data show DES is standard among medical students, yet the academic impact and local determinants remain underexplored [14], [15].

Pathophysiology and Risk Factors

DES is multifactorial. Reduced and incomplete blinking during sustained screen viewing destabilizes the tear film, increases corneal exposure, and promotes evaporative dryness; continuous accommodative and convergence effort at near distances contributes to asthenopia; and poor posture drives neck/shoulder strain [3], [5]. Experimental work suggests blue-light exposure can induce oxidative stress in retinal pigment epithelial cells, though intensities from typical consumer devices are far below harmful laboratory thresholds [16], [17], [18], [19], [20], [21].

Consistently reported risk factors include longer daily screen time, close viewing distance, suboptimal lighting and posture, female sex, and low adherence to visual-hygiene practices [12], [22], [23]. Problematic internet use has also been associated with symptomatic dry-eye

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complaints among students, indicating behavioral contributors to ocular surface stress [24].

Practical preventive measures such as the 20-20-20 Rule, adequate ergonomics, and scheduled visual breaks are widely advocated to reduce symptoms and accommodative fatigue [5], [12]. Academic Implications and Rationale

For medical students, especially those in the clinical years, persistent visual discomfort, fatigue, and fluctuating clarity can impair sustained reading, digital documentation, and clinical learning efficiency, with potential downstream effects on academic performance and well-being [8], [25]. Despite substantial global literature, there is a specific evidence gap regarding the prevalence, determinants, and academic consequences of DES among Sudanese clinical-year medical students.

Accordingly, this study will estimate the prevalence of DES, identify modifiable behavioral and ergonomic determinants, and evaluate its relationship with academic performance among clinical-year medical students at the University of Bahri, Khartoum State, Sudan. The findings aim to inform targeted, evidence-based interventions spanning visual hygiene education, ergonomic optimization, and digital-use policies to safeguard ocular health and support academic resilience in an increasingly digitized medical education environment.

Literature Review

1) Concept and Symptom Cluster

Digital Eye Strain, often referred to as Computer Vision Syndrome, is a multifactorial condition triggered by prolonged use of digital devices [2], [3], [26]. It presents with visual, ocular-surface, and extraocular symptoms [2], [3], [26]. Mechanisms include reduced and incomplete blinking, which destabilizes the tear film; sustained accommodative/convergence effort at near distances; and ergonomic stressors such as poor posture, glare, and suboptimal lighting [5].

2) Epidemiology in University and Medical Students

DES is highly prevalent in university populations and is consistently elevated among medical students due to intensive screen use for lectures, clinical documentation, research, and exam preparation [2], [3], [7], [8], [10], [13]. Multiple cross-sectional investigations report that over half of students meet symptomatic thresholds, with some cohorts approaching very high symptom counts [12], [13], [27], [28]. During and after the COVID-19 shift to online learning,

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symptom burden and dry-eye complaints rose further in many settings [3], [7], [8], [10], [12], [28].

Context-specific evidence

- **Thailand:** DES prevalence 57.6% [29], [30]. Risk increased with ≥9 hours/day of screen use [31], viewing distance <30 cm [29], and not using blue-light filters. Use of artificial tears was linked to lower symptom severity.
- **Jordan: DES**: prevalence 56.3% [32]. Dry eyes and headaches were most common [33]; longer screen time correlated with greater symptom severity.
- Sudan University of Khartoum: Very high symptom burden: 94% had ≥1 symptom, and 72.4% had ≥3 symptoms. Neck/shoulder pain and headache predominated. Most students used screens ≥5 h/day, and awareness of the 20-20-20 Rule was low. Slouched posture markedly increased the odds of ≥3 symptoms [14], [15].
- These data confirm heavy exposure and high symptom burden in medical trainees, while also highlighting modifiable determinants relevant to your target population.

3) Risk Factors and Determinants

Exposure-related: longer daily screen time, cumulative weekly hours, and continuous sessions without breaks. Visual task demands: close viewing distance, small font, high visual complexity. Ergonomic environment: slouched/bent posture, improper screen height, glare, and suboptimal lighting. Behavioral/awareness: low adherence to visual-hygiene practices, low awareness of blink training, and variable hydration/lubrication habits. Individual factors: sex differences are frequently reported; uncorrected refractive errors and pre-existing ocular-surface instability can amplify symptoms. Protective behaviors: appropriate use of lubricating drops; adherence to scheduled visual breaks; ergonomic optimization; adequate ambient illumination; and sufficient viewing distance.

The Thailand and Sudanese cohorts particularly underscore the dose–response nature of screen time and the influence of posture and viewing distance on symptom load, while also pointing to simple, actionable mitigations.

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4) Pathophysiology Snapshot

- Ocular surface: Reduced/incomplete blinking → tear-film instability → evaporative dry eye → fluctuating vision and discomfort.
- Accommodative/binocular: Sustained near work → increased accommodative and convergence demand → asthenopia, headaches, intermittent blur/diplopia.
- Musculoskeletal: Non-neutral neck/back posture → peri-cervical strain and headaches.
- Light/contrast factors: Screen luminance/contrast, and spectral output, may contribute to visual fatigue; real-world blue-light intensity from consumer devices is typically far below harmful laboratory thresholds, so the benefits of filters may be modest and user-dependent.

5) Assessment Approaches

DES remains a clinical diagnosis supported by standardized symptom questionnaires. Ancillary testing can characterize tear-film stability and binocular stress in research and clinical audits. Recently developed toolkits aim to standardize binocular-vision and ocular-surface metrics for DES research.

6) Prevention and Management

Core strategies combine behavioral pacing, blink optimization, and ergonomics. Lubricating eye drops reduce dryness-related symptoms; blue-light filters may help a subset of users, though evidence of substantial clinical benefit is mixed. Crucially, awareness and adherence remain low across many cohorts, underscoring the need for targeted education within medical curricula.

7) Impact on Sleep, Quality of Life, and Academic Function

DES is linked to fatigue and sleep disruption, which, along with visual fluctuations and headaches, can erode attention, study endurance, reading comprehension, and digital documentation speed/accuracy. For clinical-year students navigating heavy cognitive load and electronic clinical systems, these mechanisms plausibly degrade academic efficiency and perceived performance. While many studies quantify symptoms and risk factors, fewer directly measure academic outcomes, creating an actionable evidence gap.

8) Synthesis and Gap for the Present Study

Across diverse settings, DES is ordinary in clinical-year medical students and is consistently

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associated with modifiable behaviors and environments. However, the relationship between DES severity and academic performance remains under-measured, especially in Sudan. Your study addresses this gap by quantifying DES prevalence/severity, mapping behavioral/ergonomic determinants, and testing associations with self-reported academic performance in clinical-year medical students at the University of Bahri.

Problem statement and justification

1.3. 1Problem Statement

Digital Eye Strain is an emerging public health concern due to prolonged exposure to digital devices for study, clinical work, and research, causing eye fatigue, dryness, blurred vision, headaches, and difficulty focusing. Its impact on cognitive function and academic performance remains unclear, particularly among medical students. While prevalence is high up to 94% locally and 66–83% globally, few studies have examined its effect on academic outcomes. This study aims to evaluate the association between DES severity and self-reported academic performance among clinical-year students at the University of Bahri.

1.3. 2Justification

Clinical-year medical students are highly exposed to digital screens for lectures, studying, clinical work, and research, increasing their risk of Digital Eye Strain. While DES prevalence is documented globally, its impact on academic performance remains unclear, particularly in Sudan. Local studies assessed DES symptoms but did not examine their relationship with academic outcomes or specifically consider clinical-year students.

Persistent DES symptoms, such as eye fatigue, headaches, blurred vision, and difficulty focusing, can impair concentration and learning. This study, therefore, aims to provide context-specific evidence on the association between DES severity and academic performance, thereby informing strategies to enhance student well-being and educational outcomes.

1.4 Objectives

1.4.1 General objective:

Assess the association between Digital Eye Strain and academic performance among clinical-

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year medical students at the University of Bahri, Khartoum State, Sudan, 2025.

1.4.2 Specific objectives:

1. To assess the severity of DES symptoms among clinical-year medical students at the University of Bahri through a structured questionnaire.
2. To evaluate the visual hygiene practices of clinical-year medical students related to screen use, including duration of use, breaks, posture, and lighting conditions, using an objective self-reported questionnaire.
3. To explore the association between the severity of DES symptoms and self-reported academic performance, measured by categorized GPA ranges, among clinical-year medical students. This investigation provides crucial insights into the prevalence of DES among this specific demographic and its relationship to their academic achievements.

2. METHODOLOGY

2.1 Study Design:

This study used a cross-sectional, descriptive-analytical design conducted in 2025 to assess Digital Eye Strain (DES), visual hygiene practices, and their association with academic performance among clinical-year medical students at the University of Bahri.

2.2 Study Area:

This study was conducted at the University of Bahri, a public higher education institution located in Khartoum, Sudan. The university comprises 18 faculties, including the Faculty of Medicine, where this research was conducted. The Faculty of Medicine is situated in Khartoum 3, west of Al-Qurashi Garden and east of Sudan Medical Supplies, along Ahmed Khair Street. It was established in 2011 following the relocation of faculties from Southern Sudan after the secession. The faculty adopts a semester-based curriculum that integrates teaching of basic sciences, clinical training, and professional competencies.

2.3 Study Population:

The study targeted clinical-year medical students (years 4, 5, and 6) enrolled at the Faculty

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ahri. According to official university records, the total number of
year medical students at the University of Bahri, Khartoum State, Sudan, 2025.

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students in these clinical years was 643. These records provided verified enrollment data for each academic year.

2.3.1 Inclusion criteria:

Students currently registered in clinical years 4th, 5th, and 6th at the University of Bahri.

2.3.2 Exclusion criteria:

1. Students with previously diagnosed ocular diseases or conditions.
2. Students enrolled in pre-clinical years (years 1, 2, and 3).
3. Students who refuse to participate or fail to complete the questionnaire.

2.4 Study Period:

This cross-sectional study was conducted from August 01 to September 15, 2025.

2.5 Sample Size and Sampling Techniques:

The study population included 643 clinical-year medical students at the University of Bahri (6th year: 215; 5th year: 246; 4th year: 182). The sample size was calculated using Slovin's formula:

n = {N}/{1 + N. e^2}

Where:

{N} is the total population, and N=643

{e} is the margin of error, e=0.05

Substituting these values, the minimum sample size was n=247 students. To compensate for potential non-response or dropouts, 10% was added, resulting in a final sample size of 272 students. Although Slovin's formula provided an estimated sample, a full coverage approach was adopted by inviting all eligible students to participate, thereby ensuring representativeness and minimizing selection bias. The sample was distributed proportionally across academic years: 6th year = 91 (33.5%), 5th year = 104 (38.2%), and 4th year = 77 (28.3%).

2.6 Data Collection Tools:

Section A collected demographic data and informed consent from participants, including gender, academic year, and voluntary participation in the study.

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Section B employed a modified version of the standardized Computer Vision Syndrome Questionnaire (CVS-Q), originally developed and validated by Seguí et al. (2015), to assess the severity of Digital Eye Strain (DES) symptoms among clinical-year medical students (14). The original scoring system, based on symptom frequency and intensity, was preserved with minor modifications to suit the academic context.

Visual hygiene practices related to digital screen use were assessed through a structured questionnaire developed by the research team. This section consisted of seven questions addressing key domains such as screen time, break patterns, posture, and ambient lighting. Participants were asked to select responses that reflect their typical behaviors during academic activities. Responses were assigned numerical scores to quantify the quality of visual hygiene practices. For frequency-based questions (e.g., break patterns, maintaining appropriate distance, adjusting brightness), scores ranged from 0 (poor practice) to 3 (optimal practice), allowing classification of overall visual hygiene into good, moderate, or poor categories.

Section D collected self-reported academic performance data, categorized by GPA range, to explore the association between DES symptoms, visual hygiene practices, and academic outcomes.

2.7 Data Analysis:

Data were analyzed using SPSS version 26. Descriptive statistics were presented as frequencies and percentages, and visualized through tables and figures. For analytical purposes, data normality was tested using histograms. The Mann–Whitney U and Kruskal–Wallis tests were applied to determine associations between categorical variables, and the corresponding p-values were reported.

Participants were classified as having digital eye strain (DES) if their total questionnaire score was six or higher. This cut-off point was adopted from the validated Computer Vision Syndrome Questionnaire (CVS-Q) developed by María del Mar Seguí et al. (2015), which demonstrated a sensitivity of 85.2% and a specificity of 76.5% for this threshold(14). Using the same criterion ensured comparability with previous studies and strengthened the validity of DES classification in the present research.

2.8 Ethical Considerations:

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Ethical approval was sought from the Research Ethics Committee of the University of Bahri and the Faculty of Medicine Research Committee. Participants were clearly informed of the study's objectives, and written informed consent was obtained prior to enrollment. Participation was entirely voluntary, and students retained the right to withdraw from the study at any time without penalty or consequences. All collected data was handled with the highest level of confidentiality and stored securely. The findings were used exclusively for academic and research purposes.

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RESULTS

1. Demographic Characteristics

A total of **272 clinical-year medical students** from the University of Bahri participated in this cross-sectional study. The cohort included **162 females (59.6%)** and **110 males (40.4%)**. Most participants were aged **23–25 years (60.3%)**, while **34.2%** were older than 25 years, and **5.5%** were aged 20-22 years.

These distributions indicate a young adult population representative of clinical-year medical students in Sudan.

Table 1. Sociodemographic Characteristics of Participants (N = 272)

Variable	Category	n	%
Age (years)	20–22	15	5.5
23–25	164	60.3	
>25	93	34.2	
Gender	Female	162	59.6
Male	110	40.4	

2. Prevalence and Frequency of Computer Vision Syndrome (CVS) / Digital Eye Strain (DES) Symptoms

A high proportion of respondents reported one or more symptoms of CVS/DES (Table 2). When combining “occasionally” and “often,” the most common complaints were eyestrain (86.7%), eye fatigue (85.0%), and difficulty focusing (83.4%).

Ocular Discomfort:

Eyestrain was the predominant symptom reported *occasionally* by 175 (64.3%) and *often* by 61 (22.4%). Eye dryness was also highly prevalent, affecting 193 (71.0%) in total.

Systemic and Musculoskeletal Symptoms:

Headache was reported by 243 (89.4%) (49.3% occasionally, 40.1% often), while neck, shoulder, or back pain affected 231 (84.9%), confirming the involvement of extraocular strain.

Symptom Intensity:

Most cases were mild to moderate, with only a small subset experiencing severe manifestations.

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Table 2. Frequency of Key Ocular and Musculoskeletal Symptoms Related to CVS (N = 272)

Symptom	Never n (%)	Occasionally n (%)	Often n (%)
Eyestrain	36 (13.2)	175 (64.3)	61 (22.4)
Eye dryness	79 (29.0)	139 (51.1)	54 (19.9)
Headache	29 (10.7)	134 (49.3)	109 (40.1)
Eye fatigue	41 (15.1)	162 (59.6)	69 (25.4)
Difficulty focusing	45 (16.5)	151 (55.5)	76 (27.9)
Photophobia (light sensitivity)	68 (25.0)	146 (53.7)	58 (21.3)
Musculoskeletal pain (neck/shoulder/back)	41 (15.1)	118 (43.4)	113 (41.5)

3. Visual Hygiene Practices

Adherence to visual hygiene practices was generally poor (Table 3).
Only 25 students (9.2%) consistently followed the 20-20-20 Rule, while 58.1% took breaks *only when discomfort occurred*, suggesting reactive rather than preventive behavior.
Regarding posture and ergonomics, only 37 (13.6%) maintained the recommended 50–70 cm viewing distance. Environmental conditions were also suboptimal: 21.7% worked in dim lighting and 23.5% under glare. Screen brightness adjustment was practiced by 25.7% of participants.

Table 3. Adherence to Visual Hygiene Practices (N = 272)

Practice	Category	n	%
Following 20-20-20 rule	Always	25	9.2
Sometimes	87	32.0	
Rarely	78	28.7	
Never	82	30.1	
Break frequency (> 1 hr use)	Every hour	34	12.5
Every 2–3 hours	45	16.5	
Only when discomfort occurs	158	58.1	
No breaks	35	12.9	
Viewing distance (50–70 cm)	Always	37	13.6
Sometimes	81	29.8	
Rarely	88	32.4	

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Never	66	24.3	
Lighting condition	Well-lit	57	21.0
Dim	59	21.7	
Bright/glare	64	23.5	
Variable	92	33.8	
Screen-brightness adjustment	Always	70	25.7
Sometimes	91	33.5	
Rarely	69	25.4	
Never	42	15.4	

These data reveal limited ergonomic awareness among medical students, with high reliance on reactive coping strategies rather than preventive habits.

4. Academic Performance Distribution

Self-reported Grade Point Averages (GPA) were generally high, with most students in the "Good" or "Very Good" categories (Table 4).

Table 4. Distribution of Self-Reported GPA (N = 272)

GPA Category	n	%
3.50 – 4.00 (Excellent)	49	18.0
3.00 – 3.49 (Very Good)	82	30.1
2.00 – 2.99 (Good)	121	44.5
< 2.00 (Fair/Poor)	20	7.4

5. Association Analyses

5.1 Association Between CVS Severity and Academic Performance

Inferential analysis using the **Mann–Whitney U test** demonstrated **no statistically significant association** between CVS severity and GPA (**p = 0.779**) (Table 5).

Although students with higher CVS scores tended to have marginally lower GPAs, the relationship was not statistically meaningful.

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Table 5. Association Between CVS Severity and Academic Performance

GPA Category	Not Having CVS n (%)	Having CVS n (%)	p-value
Below 2.00	0 (0.0)	18 (100.0)	
2.00 – 2.99	2 (1.7)	119 (98.3)	
3.00 – 3.49	2 (2.4)	80 (97.5)	
3.50 – 4.00	2 (4.1)	47 (95.9)	**0.779**

This suggests that despite a high prevalence of CVS symptoms, academic performance was not significantly affected in measurable GPA outcomes.

5.2 Association Between Visual Hygiene and CVS Severity

The **Kruskal–Wallis test** similarly revealed **no significant association** between visual hygiene category and CVS severity (**p = 0.526**).

Students reporting *good*, *moderate*, or *poor* visual hygiene demonstrated comparable CVS severity scores.

Table 6. Association Between Visual Hygiene and CVS Severity

Visual Hygiene Category	Not Having CVS n (%)	Having CVS n (%)	p-value
Good	2 (33.3)	23 (8.7)	
Moderate	1 (16.7)	122 (42.4)	
Poor	3 (50.0)	119 (45.1)	**0.526**

These findings confirm that although poor visual habits are everyday, their statistical relationship with symptom severity remains insignificant in this cohort.

6. Summary of Key Findings

1. **High prevalence of CVS/DES:** Over half of respondents reported ocular or musculoskeletal discomfort associated with digital screen use.
2. **Predominantly mild to moderate symptoms:** Severe manifestations were infrequent.
3. **Suboptimal visual hygiene practices:** Very few participants followed preventive measures such as the 20-20-20 Rule.
4. **No significant association with academic outcomes:** CVS severity did not correlate with GPA (p = 0.779).
5. **No measurable impact of hygiene level on CVS severity:** Behavioral factors showed a non-significant influence (p = 0.526).

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Discussion

4.1 Principal findings

This study analyzed 272 clinical-year medical students at the University of Bahri. Students commonly reported multiple DES symptoms during digital device use *[9], [28]*. While eyestrain, dryness, and headache were frequent, most symptom severities were predominantly mild *[34]*. Extraocular complaints were also notable, highlighting the contribution of posture and ergonomics *[28], [35]*.

Preventive behaviors were suboptimal: only 9.2% consistently applied the 20-20-20 Rule, 13.6% maintained an appropriate viewing distance, and 58.1% took breaks only when discomfort occurred *[3], [36], [37]*. Despite this high symptom burden and low adherence to visual-hygiene practices, no statistically significant associations were found between DES severity and GPA or between visual-hygiene practices and DES severity.

4.2 Comparison with prior studies

The findings align with international evidence showing high DES prevalence among university and medical students, particularly after the shift to online learning *[13], [15], [28], [38], [39]*. Symptom profiles in our cohort mirror those reported widely among medical trainees *[28], [40]*.

Thailand: Reported DES prevalence was 57.6%, with risk factors including ≥9 hours/day of screen time, viewing distance <30 cm, and not using blue-light filters *[29]*. Our cohort showed similar behavioral patterns, but these behaviors were not significantly associated with DES severity. The difference may reflect differences in sample size, variable definitions of behaviors, and the inclusion of additional hygiene variables in our analysis. Unlike the Thai study, we also assessed academic outcomes and found no association between DES severity and academic outcomes.

Jordan: DES prevalence was 56.3%, with dry eyes and headaches most common, and a significant correlation between extended screen time and symptom severity *[32], [41]*. Our cohort reported higher frequencies of several symptoms, but predominantly mild severity. We did not detect a significant association between hygiene behaviors and symptom severity, possibly due to design differences, contextual variation in digital learning intensity,

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or narrower behavioral variability within our sample.

Sudan: A very high symptom burden was reported; neck/shoulder pain and headache predominated [14], [15]. Our frequencies were lower for some complaints, with mild severity overall, but patterns of low awareness and limited adherence to protective practices were shared. Notably, the Khartoum study found posture was significantly associated with symptom severity. In contrast, our broader hygiene index did not reach significance, again suggesting that specific ergonomic factors may exert more potent effects than composite behavior scores [15], [35].

Together, these comparisons show consistently high exposure and symptom burden in medical trainees regionally and internationally, with context-dependent differences in risk gradients and measured associations [5], [13].

4.3 Potential mechanisms

The symptom complex is plausibly explained by:

- **Ocular surface stress:** reduced and incomplete blinking during prolonged screen tasks: tear-film instability, evaporative dry eye, fluctuating clarity [5], [35].
- Accommodative/binocular load: sustained near work and high visual complexity asthenopia, intermittent blur/diplopia, headache [35].
- Musculoskeletal strain: non-neutral neck/back posture and suboptimal workstations, neck/shoulder pain, and tension headaches [28], [35].
- Sleep/circadian effects: late-evening exposure and high screen time can disturb sleep patterns, potentially compounding fatigue and perceived visual strain [38], [42], [43].

4.4 Visual-hygiene behaviors and DES severity

Although adherence to hygiene practices was generally low, we found no significant association between our visual-hygiene composite and DES severity. Several explanations are plausible:

1. Limited between-group variability behaviors were uniformly poor, reducing contrast.
2. Self-report bias in behaviors dilutes actual effects.
3. Specific factors vs composites individual variables may drive symptoms more strongly than aggregated indices, consistent with the Khartoum posture finding [15], [35].

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4. Symptom adaptation students may employ informal coping not captured by our measures.
5. Despite statistical non-significance, the behavioral pattern remains clinically relevant: education on viewing distance, posture, task lighting, conscious blinking, and scheduled breaks is justified [3], [36], [44].

4.5 DES severity and academic performance

We observed no significant association between DES severity and self-reported GPA. Potential explanations include:

- **Adaptation and resilience:** clinical-year students face sustained digital demands and may maintain performance via coping strategies and prioritization.
- **Outcome insensitivity:** GPA may be too coarse to detect decrements in study efficiency, reading endurance, or task accuracy.
- **Timing effects:** symptoms may be intermittent or clustered around intensive digital tasks, with limited impact on cumulative GPA.
- Even without measurable GPA effects, DES could still indirectly impair learning through fatigue, reduced concentration, and lower reading/comprehension efficiency, meriting prevention.

4.6 Strengths and limitations

This study has several strengths. It targets explicitly clinical-year medical students, a population with high exposure to digital screens, and simultaneously evaluates symptoms, behavioral and ergonomic factors, and academic outcomes. Furthermore, it provides valuable contextualized comparisons with both regional and international cohorts, adding depth to its findings. However, some limitations must be acknowledged. The cross-sectional design prevents causal inference, and the reliance on self-reported data for exposures, symptoms, and GPA introduces a risk of misclassification. Additionally, ceiling effects may have limited the detection of

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between-group differences, and most reported symptoms were mild, which could have attenuated observed associations. The absence of objective measures, such as ergonomic assessments, screen-time tracking, and ocular surface testing, also limits the study's mechanistic insight.

Implications and Recommendations: Educational and policy interventions should include brief visual-hygiene curricula during the clinical years. Environmental improvements are needed to optimize study areas and computer laboratories. In terms of self-care, students should be encouraged to use lubricating eye drops when appropriate, structure their schedules to alternate between screen and non-screen activities, and minimize late-evening screen exposure to protect sleep quality. For future research, it is recommended to incorporate objective screen-time analytics, validated posture and ergonomic assessments, and ocular surface testing. Prospective study designs and more sensitive academic performance measures would also strengthen the evidence base and clarify causal pathways.

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Conclusion

Among 272 clinical-year medical students at the University of Bahri (59.6% female; mostly aged 23–25), DES symptoms were common, with eyestrain (64.3%), eye fatigue (59.6%), dryness (51.1%), and headache (49.3%)being the most common. Prolonged daily screen use was typical, yet only 9.2% consistently followed the 20 20–20 rule; posture and lighting problems were also common. There were no significant associations among DES severity, visual hygiene practices, or self-reported academic performance ($p>0.05$). Nonetheless, the pattern suggests that extended screen exposure and poor visual habits likely aggravate ocular discomfort and may reduce visual efficiency, warranting preventive action.

Recommendations

1. **Awareness & training:** brief programs on 20–20–20, conscious blinking, posture, and task lighting.
2. **Ergonomics:** ensure proper viewing distance/height, glare control, and adjustable seating in study areas.
3. **Preventive measures:** encourage planned screen breaks; consider lubricating drops; blue-light filters may help some users.
4. **Curriculum integration:** embed DES prevention and workstation setup in clinical-year skills training.
5. **Further research:** multi-center, longitudinal studies using objective screen-time/ergonomic metrics and ocular-surface tests. This research should also explore the effectiveness of various interventions in mitigating DES symptoms and improving academic performance *[33] [45]*.

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Author Contribution

- Ziryab Imad Taha Mahmoud: Led the study concept and design, supervised data collection and methodology, contributed to data interpretation, and drafted and revised the manuscript.
- Rayan Fathelrahman Ahmed Ali: Contributed to data collection, literature review, data entry, and analysis, and supported manuscript drafting and final editing.
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- All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

Declaration of Competing Interests

The authors declare that they have no conflicts of interest related to this study.

Ethical Considerations :

Ethical approval for this study was granted by the Institutional Review Board (IRB) of the University of Bahri, Sudan. Additional administrative permission was obtained from the relevant academic department. Written informed consent was obtained from all participants prior to data collection. Confidentiality, anonymity, and voluntary participation were ensured throughout the study.

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References

[1] S. Bhattacharya, P. Heidler, S. M. Saleem, and R. R. Marzo, "Let There Be Light—Digital Eye Strain (DES) in Children as a Shadow Pandemic in the Era of COVID-19: A Mini Review," *Frontiers in Public Health*, vol. 10. Frontiers Media, August 11, 2022. doi: 10.3389/fpubh.2022.945082.

[2] I. A. Pavel *et al.*, "Computer Vision Syndrome: An Ophthalmic Pathology of the Modern Era," *Medicina*, vol. 59, no. 2. Multidisciplinary Digital Publishing Institute, p. 412, February 20, 2023. doi: 10.3390/medicina59020412.

[3] K. Kaur *et al.*, "Digital Eye Strain- A Comprehensive Review," *Ophthalmology and Therapy*, vol. 11, no. 5. Adis, Springer Healthcare, p. 1655, July 09, 2022. doi: 10.1007/s40123-022-00540-9.

[4] E. W. Anbesu and A. K. Lema, "Prevalence of computer vision syndrome: a systematic review and meta-analysis," *Scientific Reports*, vol. 13, no. 1. Nature Portfolio, January 31, 2023. doi: 10.1038/s41598-023-28750-6.

[5] J. S. Wolffsohn *et al.*, "TFOS Lifestyle: Impact of the digital environment on the ocular surface," *The Ocular Surface*, vol. 28. Elsevier BV, p. 213, April 01, 2023. doi: 10.1016/j.jtos.2023.04.004.

[6] A. Aldukhayel, S. M. Baqar, F. K. Almeathem, F. S. Alsultan, and G. A. AlHarbi, "Digital Eye Strain Caused by Online Education Among Children in Qassim Region, Saudi Arabia: A Cross-Sectional Study," *Cureus*, Apr. 2022, doi: 10.7759/cureus. 23813.

[7] C. V. Anthrayose, A. Joju, R. Puthiyedath, N. C. Babu, and A. R. Rajan, "Eyestrain and associated problems among undergraduate medical students undergoing e-learning/teaching methods during the COVID-19 pandemic," *Indian Journal of Clinical and Experimental Ophthalmology*, vol. 7, no. 2, p. 308, Jun. 2021, doi: 10.18231/j.ijceo.2021.062.

[8] V. M. Victor *et al.*, "A Web-Based Cross-Sectional Survey on Eye Strain and Perceived Stress amid the COVID-19 Online Learning among Medical Science Students," *International Medical Education*, vol. 2, no. 2, p. 83, May 2023, doi: 10.3390/ime2020008.

[9] F. Jakhar *et al.*, "Dry eye symptoms and digital eyestrain - Emerging epidemics

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among university students due to online curriculum amid the COVID-19 pandemic. A cross-sectional study," *Indian Journal of Ophthalmology*, vol. 71, no. 4, p. 1472, Apr. 2023, doi: 10.4103/ijo.ijo_2760_22.

[10] N. M. Lotfy, H. M. Shafik, and M. Nassief, "Risk factor assessment of digital eye strain during the COVID-19 pandemic: a cross-sectional survey," *Medical Hypothesis Discovery & Innovation in Ophthalmology*, vol. 11, no. 3, p. 119, Dec. 2022, doi: 10.51329/mehdiophthal1455.

[11] A. Chen, N. R. Roslan, Y. H. Cosette, and S. C. Teoh, "Online Learning and Its Short-term Impact on Digital Engagement and Digital-related Health Symptoms Amongst University Students During the COVID-19 Pandemic," *Malaysian Journal of Medicine and Health Sciences*, vol. 19, no. 3, p. 138, May 2023, doi: 10.47836/mjmhs. 19.3.18.

[12] K. Bhatnagar, S. G. Dixit, L. Pandey, S. Prakash, S. Shiromani, and K. Singh, "Digital eye strain among medical students associated with shifting to e-learning during the COVID-19 pandemic: An online survey," *Indian Journal of Ophthalmology*, vol. 72, no. 1, p. 98, Dec. 2023, doi: 10.4103/ijo.ijo_492_23.

[13] M. J. Barata, P. Aguiar, A. Grzybowski, C. Lança, and A. Moreira-Rosário, "Validation of Binocular Vision and Ocular Surface Assessment Tools in Digital Eye Strain Syndrome: The DESIROUS Study," *Journal of Personalized Medicine*, vol. 15, no. 5, p. 168, Apr. 2025, doi: 10.3390/jpm15050168.

[14] M. A. Dafallah, O. A. M. Ahmed, M. M. I. Mohamed, R. A. Z. Abubakar, A. A. Ebraheem, and G. Ahmed, "Computer vision syndrome among Sudanese medical students: a growing medical issue in the digital world," *Annals of Medicine and Surgery*, Mar. 2024, doi: 10.1097/ms9.0000000000001917.

[15] H. A. G. Hassan, "Computer Vision Syndrome Among Medical Students at the University of Khartoum, Sudan: Prevalence and Associated Factors," *Cureus*, May 2023, doi: 10.7759/cureus. 38762.

[16] H. Chakravarthy, V. Georgyev, C. Wagen, A. Hosseini, and J. A. Matsubara, "Blue light-induced phototoxicity in retinal cells: implications in age-related macular degeneration," *Frontiers in Aging Neuroscience*, vol. 16. Frontiers Media, December 17, 2024. doi: 10.3389/fnagi. 2024.1509434.

WOS - East Mediterranean - © 2025 Curevance (CVN). All rights reserved

[17] X. Ouyang, J. Yang, Z. Hong, Y. Wu, Y. Xie, and G. Wang, "Mechanisms of blue light-induced eye hazard and protective measures: a review," *Biomedicine & Pharmacotherapy*, vol. 130. Elsevier BV, p. 110577, August 04, 2020. doi: 10.1016/j.biopha.2020.110577.

[18] M. García-Romera, V. Ponce-García, Ú. Torres-Parejo, and A. López-Muñoz, "Effect of Exposure to Blue Light from Electronic Devices and the Mediterranean Diet on Macular Pigment," *Journal of Clinical Medicine*, vol. 13, no. 24, p. 7688, Dec. 2024, doi: 10.3390/jcm13247688.

[19] R.-G. Antemie, O. Samoilă, and S. Clichici, "Blue Light—Ocular and Systemic Damaging Effects: A Narrative Review," *International Journal of Molecular Sciences*, vol. 24, no. 6. Multidisciplinary Digital Publishing Institute, p. 5998, March 22, 2023. doi: 10.3390/ijms24065998.

[20] A. Françon *et al.*, "Phototoxicity of low doses of light and influence of the spectral composition on human RPE cells," *Scientific Reports*, vol. 14, no. 1, Mar. 2024, doi: 10.1038/s41598-024-56980-9.

[21] I. Jaadane *et al.*, "Retinal phototoxicity and the evaluation of the blue light hazard of a new solid-state lighting technology," *Scientific Reports*, vol. 10, no. 1, Apr. 2020, doi: 10.1038/s41598-020-63442-5.

[22] M. Iqbal *et al.*, "Computer Vision Syndrome Prevalence and Ocular Sequelae among Medical Students: A University-Wide Study on a Marginalized Visual Security Issue," *The Open Ophthalmology Journal*, vol. 15, no. 1, p. 156, Sep. 2021, doi: 10.2174/1874364102115010156.

[23] R. Jain, A. Khan, V. Hegde, A. Bappal, and S. Rashmi, "Digital eye strain among undergraduate medical students in a tertiary eye care hospital of South India – A questionnaire-based study," *Indian Journal of Clinical and Experimental Ophthalmology*, vol. 5, no. 2, p. 208, Jun. 2019, doi: 10.18231/j.ijceo.2019.049.

[24] I. B. Condori-Meza *et al.*, "Problematic Internet Use Associated with Symptomatic Dry Eye Disease in Medical Students from Peru," *Clinical Ophthalmology*, p. 4357, Oct. 2021, doi: 10.2147/opth.s334156.

[25] S. C. H. Gutiérrez *et al.*, "Digital Eye Strain among Peruvian Nursing Students: Prevalence and Associated Factors," *International Journal of Environmental Research and*

WOS - East Mediterranean - © 2025 Curevance (CVN). All rights reserved

Public Health, vol. 20, no. 6, p. 5067, Mar. 2023, doi: 10.3390/ijerph20065067.

[26] A. Trailokya and S. Chaudhry, "Paradigm of digital eye strain," *The Journal of Community Health Management*, vol. 10, no. 3, p. 88, Sep. 2023, doi: 10.18231/j.jchm.2023.021.

[27] A. Basnet, S. B. Pathak, A. Marasini, R. Pandit, and A. Pradhan, "Digital Eye Strain among Adults Presenting to Tertiary Care Hospital in the Era of COVID-19 Pandemic: A Descriptive Cross-sectional Study," *Journal of Nepal Medical Association*, vol. 60, no. 245, Jan. 2022, doi: 10.31729/jnma. 7092.

[28] A. Almousa *et al.*, "The impact of the COVID-19 pandemic on the prevalence of computer vision syndrome among medical students in Riyadh, Saudi Arabia," *International Ophthalmology*, vol. 43, no. 4, p. 1275, Sep. 2022, doi: 10.1007/s10792-022-02525-w.

[29] K. Wangsan *et al.*, "Self-Reported Computer Vision Syndrome among Thai University Students in Virtual Classrooms during the COVID-19 Pandemic: Prevalence and Associated Factors," *International Journal of Environmental Research and Public Health*, vol. 19, no. 7, p. 3996, Mar. 2022, doi: 10.3390/ijerph19073996.

[30] A. Kunboon, N. Tananuvat, P. Uphapong, N. Wongpakaran, and T. Wongpakaran, "Prevalence of Dry Eye Disease, Associated Factors and Impact on Quality of Life among Medical Students during the Covid-19 pandemic," *Research Square (Research Square)*, Sep. 2024, doi: 10.21203/rs. 3. rs-4818851/v1.

[31] C. Supiyaphun, P. Jongkhajornpong, S. Rattanasiri, and K. Lekhanont, "Prevalence and risk factors of dry eye disease among University Students in Bangkok, Thailand," *PLoS ONE*, vol. 16, no. 10, Oct. 2021, doi: 10.1371/journal.pone.0258217.

[32] Y. Gammoh, "Digital Eye Strain and Its Risk Factors Among a University Student Population in Jordan: A Cross-Sectional Study," *Cureus*, Feb. 2021, doi: 10.7759/cureus. 13575.

[33] D. Abdulmannan *et al.*, "Visual health and prevalence of dry eye syndrome among university students in Iraq and Jordan," *BMC Ophthalmology*, vol. 22, no. 1, Jun. 2022, doi: 10.1186/s12886-022-02485-w.

[34] A. M. Almalki, M. Alblowi, A. M. Aldosari, R. Khandekar, and S. A. Al-Swailem, "Population perceived eye strain due to digital devices usage during the COVID-19

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pandemic," *International Ophthalmology*, vol. 43, no. 6, p. 1935, Dec. 2022, doi: 10.1007/s10792-022-02593-y.

[35] J. Coronel-Ocampos, J. Gómez, A. Gómez, P. P. Quiroga-Castañeda, and M. J. Valladares-Garrido, "Computer Visual Syndrome in Medical Students From a Private University in Paraguay: A Survey Study," *Frontiers in Public Health*, vol. 10, Jul. 2022, doi: 10.3389/fpubh. 2022.935405.

[36] S. Johnson and M. Rosenfield, "20-20-20 Rule: Are These Numbers Justified?" *Optometry and Vision Science*, vol. 100, no. 1, p. 52, Dec. 2022, doi: 10.1097/opx. 0000000000001971.

[37] C. Talens-Estarelles, A. Cerviño, S. García-Lázaro, A. Fogelton, A. L. Sheppard, and J. S. Wolffsohn, "The effects of breaks on digital eye strain, dry eye and binocular vision: Testing the 20-20-20 rule," *Contact Lens and Anterior Eye*, vol. 46, no. 2, p. 101744, Aug. 2022, doi: 10.1016/j.clae.2022.101744.

[38] M. H. AbuRagheif, "Evaluation of computer vision syndrome in the sample of students from the College of Medicine/University of Kerbala, result of online learning with the isolation of COVID-19," *medRxiv (Cold Spring Harbor Laboratory)*, Sep. 2023, doi: 10.1101/2023.09.25.23295828.

[39] B. S. Kumar, "A Study to Evaluate the Knowledge Regarding Computer Vision Syndrome among Medical Students," *Biomedical & Pharmacology Journal*, vol. 13, no. 1, p. 469, Mar. 2020, doi: 10.13005/bpj/1907.

[40] S. Das, L. Kalita, and B. Sarma, "THE IMPACT OF DIGITAL DEVICES ON VISUAL HEALTH: ADDRESSING DIGITAL EYE STRAIN AND BLUE LIGHT EXPOSURE," *Journal of Population Therapeutics and Clinical Pharmacology*, Jul. 2024, doi: 10.53555/jptcp.v31i7.7185.

[41] H. Alkousheh *et al.*, "The hidden cost of digital learning: a cross-sectional study assessing the prevalence of computer vision syndrome (CVS) among medical students in Jordan," *BMJ Open*, vol. 15, no. 1, Jan. 2025, doi: 10.1136/bmjopen-2024-093939.

[42] M. Ş. Aykutlu, H. C. Aykutlu, M. F. Özveren, and R. Garip, "Digital media use and its effects on digital eye strain and sleep quality in adolescents: A new emerging epidemic?," *PLoS ONE*, vol. 19, no. 12, Dec. 2024, doi: 10.1371/journal.pone.0314390.

WOS - East Mediterranean - © 2025 Curevance (CVN). All rights reserved

[43] C. Yan *et al.*, "The Relationship Between Circadian Typology and Dry Eye Symptoms in Chinese College Students," *Nature and Science of Sleep*, p. 1919, Oct. 2022, doi: 10.2147/nss.s378612.

[44] N. Aggarwal and N. U. Saba, "Digital blindness: the hidden cost of excessive screen time." *PubMed*, vol. 23, p. 631, Jan. 2024, doi: 10.17179/excli2024-7041.

[45] N. E. Ezinne, H. W. Alemu, T. C. Zeleke, K. Ekemiri, R. Mohammed, and S. James, "High Prevalence of Symptomatic Dry Eye Disease Among University Students During the COVID-19 Pandemic in the University of the West Indies, Trinidad and Tobago," *Clinical Optometry*, p. 37, Mar. 2023, doi: 10.2147/opto.s396135.

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