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Visual Fatigue and Digital Ergonomic Risks among University Students in Screen-Based Learning Environments: A Review

Nilufa Yeasmin, Nayan Debnath Pranta and Arnab Laskar
Department of Industrial Engineering & Production Engineering
Shahjalal University of Science and Technology
Sylhet-3114, Bangladesh
nilufamili2001@gmail.com, nayan34048@gmail.com, arnab.laskar01@gmail.com

Mohammad Iqbal
Vice-Chancellor
North East University Bangladesh
Sylhet-3100, Bangladesh
vc@neub.edu.bd

Salma Akhter
Professor
Department of Chemical Engineering & Polymer Sciences
Shahjalal University of Science and Technology
Sylhet-3114, Bangladesh
salma-cep@sust.edu

Abstract

The accelerated pace of digitalization of higher education has heightened the dependency of the students who use screens to engage in learning, which has become a cause of concern regarding visual fatigue and digital ergonomic hazards. This review synthesis is based on eligible articles published since 2016 to investigate the prevalence, symptomatology and determinants of Digital Eye Strain (DES) or Computer Vision Syndrome (CVS) among university students; criteria eligible articles were reviewed. The evidence suggests that prevalence rates are always high, and they are usually between 60-90. Eye strain, eye dryness, eye burning, blurred vision and eye irritation are common ocular symptoms and other extraocular symptoms such as a headache, pains in the neck and shoulders are indicative of the musculoskeletal burden. The most promising risk factors to be considered included prolonged screen time (especially more than four to eight hours in a day of continuous screen time without taking breaks), short viewing distance, improper placement of the screen, brightness, glare, and insufficient ambient light. Poor observance of preventive measures like the 20-20-20 rule and low blink rate are other factors that cause behavioral determinants that promote the severity of the symptoms. Although well associated, the majority of studies are based on cross-sectional and self-reported information, which cannot be considered causal relationships; hence, the review highlights the necessity to introduce standardized assessment systems, longitudinal studies, and combined ergonomic interventions. Visual fatigue seems to be a common but adjustable health issue that should be addressed by institutions in online academic settings.

Keywords
Visual fatigue; Computer Vision Syndrome; Digital Eye Strain; Screen-based learning; Digital ergonomics.
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1. Introduction
The high rate of digitalization of higher education has radically changed learning environments with the world experiencing screen-based learning as a major way of instruction. The use of laptops, tablets, and smartphones in the educational setting is viewed as an essential requirement in the 21st century, as computers and video display terminals (VDTs) have become an inseparable part of the personal, professional, and academic experience, greatly decreasing the number of learning materials that students have to rely on paper-based resources (Maqbool et al., 2024). This has resulted in a radical shift in the amount of screen time among college students, who now spend between 6 and eight hours a day engaging with digital media (Wolffsohn et al., 2023). The COVID-19 pandemic has become a significant trigger of this change because it has led to a sudden and obligatory switch to virtual classes and online curriculums that have increased the involvement of students with digital devices (Yaacob et al., 2022).

Although digital learning provides a high level of flexibility and access rates to educational sources, the development of screen-based space has brought about new health hazards, namely, visual fatigue and digital ergonomic issues. Concern is increasingly growing that an excess and uncontrolled screen exposure is causing a modern health epidemic, which has commonly been termed a lifestyle epidemic of ocular surface disease and visual strain (Wolffsohn et al., 2023). Although these devices are everywhere, in a tertiary setting, there is often little in the way of organised visual ergonomic advice or formal workstation guidelines. This lack of official supervision frequently causes students to develop poor viewing habits and dysfunctional postures, i.e., bending forward or using gadgets in the dark, which can have adverse health and productivity impacts on their long-term health.

The theoretical basis of these issues is the so-called Digital Eye Strain (DES) or Computer Vision Syndrome (CVS) (Hung et al., 2026). According to the definition of American Optometric Association, CVS is a set of eye and vision-related issues that occur due to the long-term and continuous use of digital devices, such as computers, tablets, e-readers, and cell phones(Wolffsohn et al., 2023). The visual fatigue pathophysiology is complex, and it includes three processes ocular surface, extraocular, and accommodative mechanisms (Alkousheh et al., 2025). Symptoms of the ocular surface, usually brought about by a low blink rate when using the screen, include dryness, burning, redness and irritation (Noreen et al., 2016). The symptoms that are caused by accommodative mechanisms include blurred vision, double vision, and difficulty refocusing on the close targets (Alkousheh et al., 2025). Extraocular symptoms occur in the form of musculoskeletal symptoms such as headaches, neck pain, shoulder pain, and back pain, which are often associated with poor workstation ergonomics (Bagaji & Rao, 2025).

An overview of the literature done in this area of study identifies that visual fatigue is very common among students in universities around the world. CVS symptoms have been reported in about 64% to 90% of computer using populations with regional prevalence among medical and engineering students up to 97% . The most frequent predictors that have been detected in different settings are female gender, the presence of refractive errors, and long daily screen time longer than four to six hours (Maqbool et al., 2024). Nevertheless, the evidence available is mostly partial, single or context-related. Much of the existing studies dwell on the particular academic field, i.e., medical or engineering students, or is limited to the circumstances of the pandemic period (Al Ashkar et al., 2024). The results are often different because of the differences between the institutional policy, the digital behaviors in the areas, and the devices that are mostly used to learn (Al Ashkar et al., 2024).

Moreover, major digital and visual ergonomic risk factors related to screen-based learning have been determined, and they are usually investigated separately. They are inappropriate viewing distance (not more than 50 cm), suboptimal ambient light, overbright screens, and use of small-sized screen devices such as smartphones to perform academic activities (Maqbool et al., 2024). Some students have been practicing preventive strategies like 20-20-20 rule i.e., taking a 20 second pause every 20 minutes to see an object that is 20 feet away, but the level of compliance to these methods is appallingly low among the student population. According to the literature, students tend to have an awareness of the risk of eye strain, yet the necessary ergonomic literacy to arrange their learning spaces in the best visual health(Gushgari et al., 2024).

Although a lot of individual research was conducted, a large research gap in the literature still exists. Traditionally, the visual ergonomics studies concentrated on the workplace and the office professionals, and university students were underrepresented as a high-risk group. Students are a specific population that is defined by high near-working requirements, high academic stress, and portability of devices that they tend to use in the ergonomically unfavorable conditions bed or mat(Fatima et al., 2024). Moreover, digital ergonomics is often treated as musculoskeletal risk, whereas particular visual ergonomic aspects (screen resolution, refresh rates, and effects of the so-called dark mode on visual comfort) get a relatively less synergistic coverage. The methodological and conceptual inconsistencies represent also a significant challenge in the field. The existing literature tends to use diverse assessment instruments or unverified, improvised questionnaires, and it is hard to compare the results of different geographical and institutional locations (Talens-Estarelles et al., 2023).

Although the Computer Vision Syndrome Questionnaire (CVS-Q) and the Computer Vision Survey Form 3 (CVS-F3) have been used in some studies, numerous researchers do not have a consistent and standardized method of visual health assessment in higher education (Wolffsohn et al., 2023). Longitudinal data is also inadequate to determine the cumulative impact of sustained screen exposure on the ocular health of young adults who are setting lifetime trends of using digital devices. This novelty of the narrative review is that it synthesized visually fatigue, digital ergonomics and the unique features of screen-based learning in the context of higher education in an integrative and thematic manner. Instead of concentrating on one field or area, this review brings together discontinuous pieces of evidence into a consistent conceptual interpretation of the interaction between learning behaviors and environment design to influence ocular well-being. The aim is to exhibit the overlap between visual health and educational technology to discuss the two-fold burden of ocular and musculoskeletal stress that students undergo in the present digital classrooms.

2. Methods

This study was conducted as a structured literature review to synthesize evidence on ergonomic and environmental determinants of Computer Vision Syndrome (CVS) and visual fatigue among university students . A comprehensive search was performed in major electronic databases for peer-reviewed articles published between 2016 and 2025 using keywords such as “Computer Vision Syndrome,” “digital eye strain,” “visual fatigue,” “university students,” and “ergonomics,” combined with Boolean operators. Titles and abstracts were screened for relevance, followed by full-text assessment based on predefined eligibility criteria. Studies were included if they focused on university students, reported primary empirical findings on CVS or visual fatigue, and examined ergonomic, environmental, behavioral, or hardware-related determinants. Review articles, editorials, conference abstracts, and studies unrelated to academic screen exposure were excluded. After removing duplicates and ineligible studies, a total of 49 studies were included in the final analysis . Data extraction was conducted using a structured framework capturing publication year, country, study design, sample characteristics, prevalence rates, and reported risk factors. Findings were synthesized narratively and organized into thematic domains.

Key methodological steps:

- Database search (2016–2025) using predefined keywords
- Screening of titles, abstracts, and full texts
- Application of inclusion and exclusion criteria
- Inclusion of 49 eligible studies
- Structured data extraction and thematic synthesis

3. Results

3.1 Descriptive analysis

Figure 1 demonstrates the geographical distribution of the studies where these are mainly concentrated on South Asia. The highest number of studies are reported in India (n=9) and Pakistan (n=9) indicating leading advancement of this area in South Asia. Saudi Arabia (n=7) and Malaysia (n=5) also demonstrated subsequent research output. Moderate contributions were reported on Indonesia, Jordan, Ethiopia etc.

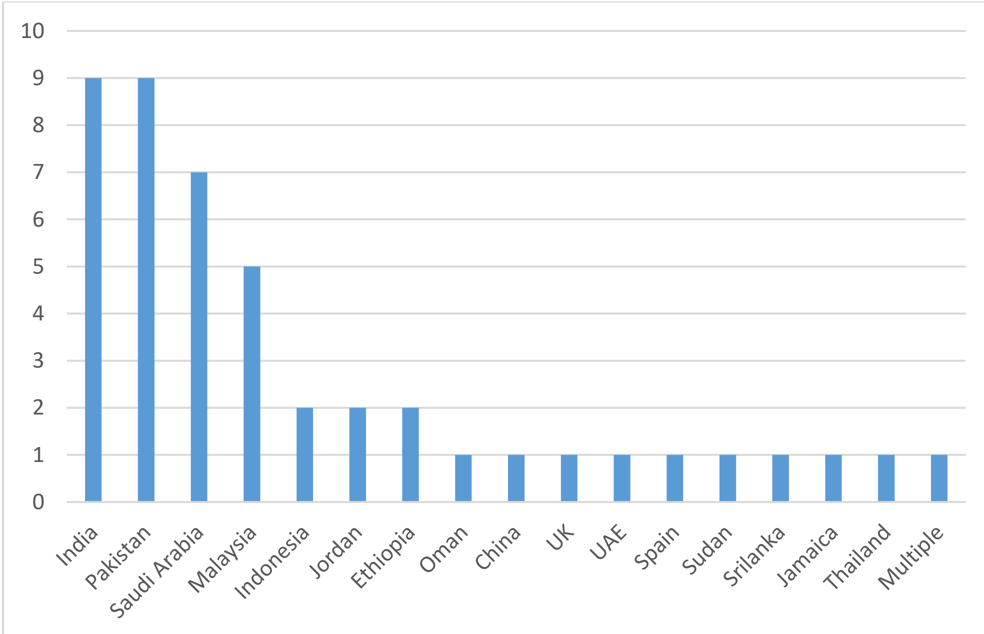

Figure 1. Geographical distribution of selected studies

Overall findings indicate that this research field is dominant on Asian countries, particularly South Asia and Middle East. Europe, Africa and other part of the world has been seen less dominant.

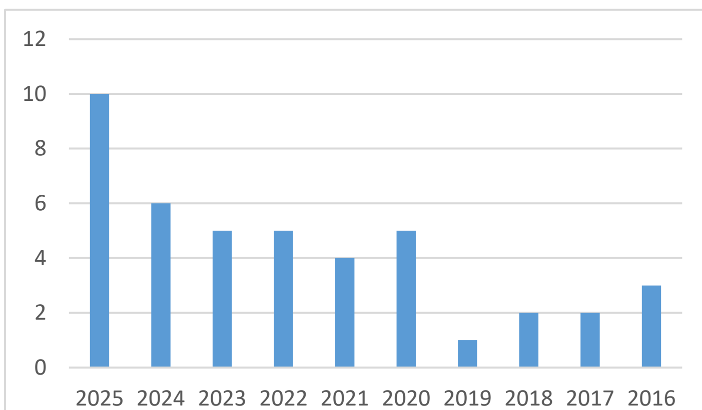

Figure 2. Year wise distribution of selected studies

Figure 2 exhibit year wise distribution of the selected studies. The highest number of publications was observed in 2025 (n = 10), followed by 2024 (n = 6). A moderate number of studies were published in 2023 (n = 5), 2022 (n = 5), and 2020 (n = 5). Slightly fewer studies were recorded in 2021 (n = 4). In contrast, earlier years showed relatively low research activity, with 2019 (n = 1), 2018 (n = 2), 2017 (n = 2), and 2016 (n = 3) publications.

Altogether, the data indicates a clear upward trend in research output in recent years. This upward trend suggests growing academic attention and expanding research engagement in the subject area in recent years.

3.2 Ocular and Extraocular Manifestations of Digital Eye Strain

Table 1 describes that ocular and extraocular symptoms were found to be prevalent among users of digital devices with a consistent high rate. The manifestations in the eye were mainly in the form of eye strain, eye dryness, burning sensation, eye itchiness, blurred vision and eye fatigue. The most common was the eye strain, with the range of 16.7 to 90.8 percent prevalence (Alkousheh et al., 2025c; Yaacob et al., 2022b). Symptoms of dry-eye were also commonly reported, with dryness levels of 78.9% being reported in some cohorts (Sah & Optom, n.d.), and burning and itching of over 50% in various studies (Bhammarkar, 2025; Sonya Arshad et al., 2019). The rates of watering and excessive tearing were 68.57% (Eldo et al., 2024) and 20.6% (Abudawood et al., 2020), respectively. These subjective results were supported by objective clinical evidence; such indicators of tear-film instability and evaporative pathology of the dry-eye as a low tear-film break-up time (mean TBUT = 7.1 seconds) and borderline Schirmer test values (12.4 mm) were noted (Saeed[1] et al., n.d.). Other research papers also claimed a reduction in the blink rate and tear-film instability as physiological outcomes of digital eye strain (Wolffsohn et al., 2023e).

Table 1. Ocular and Extraocular Manifestation of Digital Eye Strain

Study (Author, Year, Country)	**Ocular Surface Symptoms**	**Visual / Functional Symptoms**	**Headache**	**Musculoskeletal Symptoms**
(Almuqrashi et al., 2025)	Strain, fatigue (45.7%)	—	52.4%	—
(Bhammarkar, 2025)	Burning (50%), watering (49.1%)	Itching	75%	—
(AlQarni et al., 2023)	Dryness, burning	Eye pain	Yes	—
(Kanwal & Khalil, 2024)	Dry eyes	Blurred vision, fatigue	Yes	—
(Gushgari et al., 2024b)	Dryness	Fatigue, blurred vision	Yes	—
(Abou Hashish et al., 2022)	—	—	65.72%	—
(Bagaji & Rao, 2025b)	Strain (78.7%)	—	68.1%	Neck (59.4%), shoulder (55%)
(Talens-Estarelles et al., 2023b)	Dry eye, ↓ blink, TF instability	—	—	—
(Barodawala et al., 2025)	Dryness (59.6%), itching (58.6%)	—	—	—
(Fatima et al., 2024b)	Tired eyes (71.3%), strain (58.9%)	—	—	Neck/MSK pain
(Saeed[1] et al., n.d.)	↓ TBUT (7.1s), Schirmer's (12.4mm)	—	—	—
(Eldo et al., 2024)	Eye pain (69.6%), watering (68.6%)	—	83.92%	—
(Maqbool et al., 2024d)	Pain, itching	—	73.2%	—
(Cantó-Sancho et al., 2021)	Dry eyes	Strain, blurred vision	Yes	—

(Alreshidi, 2023)	Dryness (38.6%)	—	39.4%	Neck (42.5%)
(Logaraj et al., 2014)	Burning, dryness	Blurred vision	Yes	Neck/shoulder pain
(Yaacob et al., 2022b)	Strain (90.8%), burning (87.9%)	—	—	Shoulder (96.7%), neck (96.1%)
(Altalhi et al., 2020)	Dryness, burning, Itching (63%)	Strain, blurred vision, Visual change (65%)	68%	—
(Noreen et al., 2016b)	Irritation (48%), burning (33%)	Fatigue (15%)	38%	Neck/shoulder (21.8%)
(Sonya Arshad et al., 2019)	Itching (52.8%), pain (42.6%)	Photophobia	63.1%	—
(Ranasinghe et al., 2016)	Strain (31.8%), burning (27.6%)	—	45.7%	—
(Mowatt et al., 2018)	Strain (67%), burning (61.9%)	—	—	Neck (75.1%), shoulder (65.5%)
(Alkousheh et al., 2025c)	Dry (26.3%)	Strain (16.7%), blurred (15.3%)	25.9%	MSK (23.9%)
(Wangsan et al., 2022)	Dryness	Strain, blurred	Yes	—
(Al Rashidi & Alhumaidan, 2017)	Strain (62.1%)	—	Yes	Neck/shoulder
(Abudawood et al., 2020)	Tearing (20.6%)	—	—	Neck/shoulder/back (39.7%)
(Sah & Optom, n.d.)	Dry eye (78.9%)	Blurred (NSBVA 49.8%)	Yes	Neck/shoulder (62%)
(Rafi et al., 2022)	—	Photophobia (64.3%), heavy lids (62.2%)	75.5%	—
(Yuan et al., 2022)	General ocular (L3 severity)	—	—	—
(Noreen et al., 2016b)	71% ocular	—	—	29% extraocular
(Alsaad et al., 2023)	Burning	—	77%	Neck/back (84.1%)
(Thapar et al., 2025)	Ocular discomfort	—	66.2%	—

Extraocular and musculoskeletal symptoms were also very clear and were often present together with ocular symptoms. The most frequent extraocular symptom was headache with the prevalence of between 25.9% to 83.92% (Alkousheh et al., 2025c). Some of the studies reported a prevalence of headaches greater than 70 percent (Bhammarkar, 2025; Rafi et al., 2022), which implies that there is a significant neurological cost of long-term screen time. Neck and shoulder pain were also very common, 96.7% 96.1⁻ in some cohorts (Yaacob et al., 2022b) and 23-

84% in other studies (Alkousheh et al., 2025c; Alsaad et al., 2023). Back pain and musculoskeletal pains were also reported, indicating the presence of ergonomic and postural factors in the development of the symptoms.

Altogether, the produced evidence proves a universal and uniform tendency of digital eye strain with high-frequency eye surface and visual symptoms and significant extraocular ones, especially headache and musculoskeletal pain. The fact that the tear-film instability, visual fatigue and discomfort in posture are co-occurring in varied geographical locations confirms the multifactorial character of the disorder and the necessity to implement the preventive measures that can rest on the ocular and ergonomic issues.

3.3 Screen Time and Behavioral Exposure

Table 2 shows a consistent tendency to create a correlation between the increase in the daily screen exposure and the potential of digital eye strain (DES) and musculoskeletal discomfort. In the literature, the point of 8 hours a day or more often appeared to be a critical risk factor (Wangsan et al., 2022), and an exposure of over 8 hours a day was found to significantly increase the severity of symptoms (Al Rashidi & Alhumaidan, 2017; Kanwal & Khalil, 2024). Other studies have measured this relationship, with a 2.8-fold risk with more than 6 hours of screen time (Saeed[1] et al., n.d.) and a relative risk of 4.75 already exposed to devices over 4 hours per day (Jamaludin et al., 2025). The trends after the pandemic further showed a significant increase in prolonged use, with daily use of more than 5 hours increasing by more than 30 percent to 88 percent in some cohorts (Eldo et al., 2024) and the number of hours spent daily on average increasing significantly following COVID-19 (Alsaad et al., 2023). Nevertheless, a number of studies emphasized that durability of constant uninterrupted use can be even a more potent predictor of symptoms than total cumulative hours (Alkousheh et al., 2025c) and duration in certain populations was not a significantly strong predictor of the symptoms independently of ergonomic variables (Mowatt et al., 2018; Sonya Arshad et al., 2019).

Table 2. Screen Time and Behavioral Exposure

Population / Focus	**Screen Time Exposure**	**Main Risk Determinants**	**Key Outcome Summary**
Students	>6 h/day	<12 in viewing distance; poor posture	High eye fatigue prevalence
Smartphone users	Increasing over 3 yrs	100% smartphone dependence	Digital strain rose with use
Adults	Longer duration	Close viewing; no artificial tears	Ocular discomfort increased
Students	>8 h/day	Small font; low refresh rate	Higher CVS symptoms
General users	Prolonged work	Poor posture; short distance; no breaks	Strong strain association
Population sample	52.69% high exposure	Screen time linked to headache	Significant symptom link
Young adults (18–35)	Digital fatigue exposure	OWAS ergonomic risk; low awareness	Work posture risk noted
Device users	Continuous use	Reduced blink rate	Incomplete blinking effect
Smartphone users	>6 h/day	Smartphone (47.3%); dark use	Symptom increase observed
Students	Study hours prolonged	High brightness; poor 20-20-20 practice	Fatigue severity rise
Students	>6 h/day	Poor lighting; irregular breaks	OR ≈2.8 risk
Meta-analysis	High exposure	Poor ergonomics	Pooled prevalence ≈66%

Online learners	>5 h/day	Smartphone use; low blinking	Symptoms increased (30→88%)
Online students	2–8 h/day	Online class exposure	Fatigue correlated
Workers	Continuous work	Lack of scheduled breaks	Breaks reduced symptoms
Device users	Long duration	Device type; lighting	Environmental effect noted
Workers	Prolonged exposure	Posture; lighting; breaks	Risk factor cluster
Students	>4 h/day	Distance/height mismatch	Strain risk increased
Students	>4 h/day	Few breaks; lens use	CVS prevalence high
Students	>4 h/day	Sitting posture	Ergonomic risk
Adults	>6 h/day	Screen glare	Duration not main predictor
Students	Variable duration	Posture; seating position	No strong duration effect
Students	>2 h/day	Glare; distance	Symptom association
Workers	Device work	Screen height; chair design	Ergonomic setup mattered
Adults	Continuous > total hrs	Female gender	Higher susceptibility
Users	≥6 h/day	No breaks; lighting	Exposure risk confirmed
Population	>8 h/day	Time–severity relation	58.5% high exposure
Students	>3 h/day	Brightness; no 20-20-20	Symptom rise
Users	>6 h/day	Posture; breaks	Fatigue prevalence
Students	>2 h/day	Seating; breaks	Risk association
Students	<5 h/day symptomatic	Forward leaning posture	70% showed posture issue
Workers	Longer hours	Desk setup; exercise	Positive correlation
Users	>4 h/day	Low eye drop use	RR ≈4.75
Students	>6 months online	Smartphone learning	High CVS rate
New users	Longer daily hours	Adaptation level	New users higher risk
Students	4–6+ h/day	Screen above eye level	Posture risk
Online learners	<Forearm distance	Close mobile use	CVS risk increase
Students	Long duration	No antiglare; blinking	Symptom severity rise
Post-COVID users	4.29 vs 2.62 h/day	Pandemic exposure	Usage increased

Adults	>4 h/day	Daytime >3 h exposure	PR 2.1 risk

Ergonomic and behavioral risk factors were also found to be important repeatedly in the development of symptoms. The short viewing distance (less than 12 inches), incorrect screen height (most of the time above eye level), forward-leaning position, and immovable seating were constantly linked to the higher prevalence of symptoms (Almuqrashi et al., 2025; Gadain Hassan, 2023; Yuan et al., 2022). Break practices and the lack of compliance with the 20-20-20 rule were also prevalent (Abudawood et al., 2020; Bagaji & Rao, 2025b; Fatima et al., 2024b), and the lack of proper lighting, high brightness of the screens, glare, and low refresh rates only contributed to visual strain (Altalhi et al., 2020; Kanwal & Khalil, 2024). The exposure risk was increased by the device-related factors, including the prevalence of smartphone use (up to 96⁻) and the near-work-related online-learning settings (Eldo et al., 2024). Also, the modifiable behavioral factors were reported as the reduced blink rate, partial or incomplete blinking, and insufficient use of antiglare screens or lubricating drops (Wolffsohn et al., 2023e).

Taking it together, the data points to the fact that although the quantitative risk factor of prolonged screen time is significant, qualitative factors of device use, such as posture, viewing distance, lighting, break patterns, and visual hygiene contribute to the formation and intensity of digital eye strain significantly and usually synergistically.

3.4 Ergonomic and Environmental Determinants

Table 3 highlights that the digital ergonomic and environmental factors have a significant effect on the onset and degree of Computer Vision Syndrome (CVS) and visual fatigue in university students who learn through the use of a prolonged screen based learning environment. Unsuitable viewing distance was a major ergonomic risk factor all the time. Smartphones and laptops should be kept at a minimum distance of less than 12 inches and less than a forearm, respectively, as this was also found to significantly promote the likelihood of developing CVS and students were about twice as likely to develop CVS when recommended distances were not observed (Almuqrashi et al., 2025; Fatima et al., 2024b; Gushgari et al., 2024b; Noreen et al., 2016b). Increased accommodative and convergence stress is likely the mediator of this relationship.

Table 3. Ergonomic and Environmental Determinants

Category	Determinant	Impact and Findings
Ergonomic	Viewing Distance	Close device viewing increases CVS risk and visual fatigue.
Ergonomic	Sitting Posture	Forward-leaning posture and poor seating are major risk factors.
Ergonomic	Screen Alignment	Incorrect screen height relative to eye level increases strain.
Ergonomic	Furniture & Equipment	Non-adjustable workstation equipment increases discomfort.
Ergonomic	Hardware Quality	Small fonts, low refresh rate, and poor resolution increase fatigue.
Environmental	Ambient Lighting	Poor lighting or dark environment use increases ocular discomfort.
Environmental	Screen Glare	High glare exposure increases symptom severity.
Environmental	Brightness Level	Mismatch between screen and ambient brightness contributes to fatigue.
Environmental	Atmospheric Condition	Hot and dry air may worsen dry eye symptoms.
Environmental	Classroom Setup	Viewing angle and seating position influence strain development.

Both musculoskeletal and ocular symptoms were also related to postural factors. There was a close relationship between eye strain and neck discomfort and forward-leaning posture and poor body alignment, and less than a fifth of students were in ergonomically correct positioning when using a (Bagaji & Rao, 2025b; Gadain Hassan, 2023). Unexpectedly, more ocular surface exposure, tear film evaporation, and cervical strain were associated with improper positioning of the screen, especially when the monitor was set above the eye level (Eldo et al., 2024; Mowatt et al., 2018; Yuan et al., 2022). Hardware characteristics and furniture quality also had an effect on the severity of the symptoms. The absence of adjustable seats and external aids added to musculoskeletal pressure, and ergonomic changes were protective (Yaacob et al., 2022b). The visual fatigue scores were also higher with small screens, low resolution, and low refresh rate (Alsaad et al., 2023; Kanwal & Khalil, 2024)

The environmental determinants, such as poor ambient lighting, glare exposure, and brightness mismatch, were also repeatedly found to be the major risk factors (Abudawood et al., 2020; Altalhi et al., 2020; Barodawala et al., 2025). The tear film instability was also worsened by hot and dry climates (Wolffsohn et al., 2023e). In general, CVS is the result of a complex interaction between ergonomic design, environmental exposure, the quality of hardware, and the physiological vulnerability of an individual, which stresses the importance of institutional ergonomic policy and interventions based on student awareness.

4. Discussion

Analysis of the results of the forty-three studies incorporated in this review shows that digital eye strain (DES), otherwise known as computer vision syndrome (CVS), is a widespread and multi-factorial health concern among diverse populations in diverse geographical locations, i.e. Asia, Middle East, Africa, Europe, and the Caribbean. The high level of prevalence of both ocular and extraocular symptoms has been a supportive fact in the conceptual framework as characterized in the proposed model of screen-based learning exposure and effects (Figure 3). The behavioral aspects, physiological processes, digital ergonomic determinants, and outcome of symptoms are included in this diagram which, therefore, captures the complex and interconnected pathways in which long-term creen exposure causes visual fatigue.

In the reviewed literature, the eye strain, eye dryness, eye burning, eye itch, blurred vision, and eye fatigue were consistently observed with a high degree of variability in occurrence rates. Eye strain was one of the most common complaints, and the reported ranges were 16.7 90.8 (Alkousheh et al., 2025c; Yaacob et al., 2022b). Symptoms of the dry eye condition were also quite evident, where in some groups the level of dryness was 78.9 percent (Sah & Optom, n.d.) and in several cohorts the level of burning and itching was above 50 per cent (Bhammarkar, 2025; Sonya Arshad et al., 2019). Subjective symptomatology was further supported by objective clinical measurements; lower tear film break-up time and borderline values of Schirmer test showed the instability of the tear film and evaporative processes of dry eye (Saeed[1] et al., n.d.). It was found that the reduction in the blink rate and incomplete blinking, especially when working near the extended periods of time, were the major physiological mediators of the disruption of the ocular surface (Talens-Estarelles et al., 2023b).

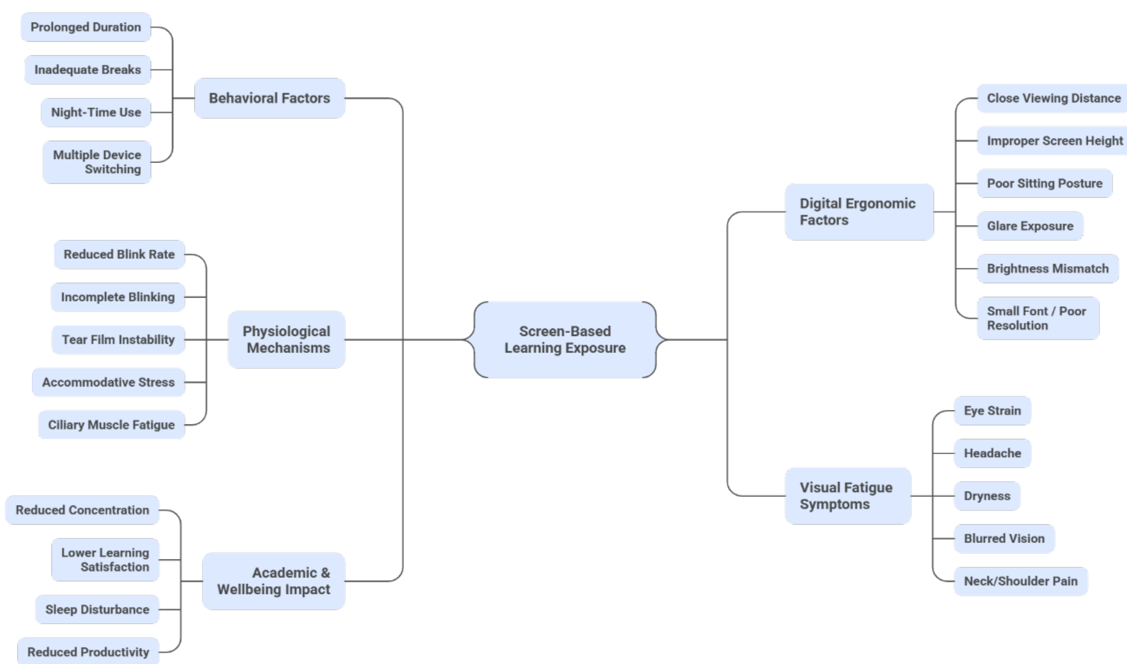

Figure 3 . Screen based learning exposure and its impact

These results are relatively consistent with the physiological mechanisms aspect in Figure 3, where accommodative stress, muscle fatigue of ciliary muscles, and tear film instability are the mediating variables between screen exposure and expression of ocular symptoms.

Extraocular symptoms were also very intense and they were often accompanied by eye complaints. Headache was a consistent finding in all studies, with varying prevalence rates between 25.9 to 83.92 (Alkousheh et al., 2025c; Eldo et al., 2024), and some studies reported a higher rate of 70 or more percent (Rafi et al., 2022). Neck and shoulder discomfort showed extremely high levels of prevalence in some groups, with 96.7 % and 96.1 % of study participants exhibiting these issues (Yaacob et al., 2022b), and musculoskeletal involvement in general was between 23 % and 84 % (Alkousheh et al., 2025c; Alsaad et al., 2023). The results support the extraocular symptom domain depicted in the model and support the hypothesis that DES goes beyond the ocular surface pathology into neuromuscular and postural domains. The visual strain and musculoskeletal symptoms coincidence indicates prolonged near fixation, forward head position, and inappropriate workstation position, which increase accommodative demand and cervical strain.
The length of screen exposure became a significant quantitative predictor, and 4-6-hours per day (or more) was often identified as a risky dose, and 8-hours per day or more was often found to be more severe (Wangsan et al., 2022), with exposure longer than 12 hours being more serious (Al Rashidi & Alhumaidan, 2017; Kanwal & Khalil, 2024). Others measured the risk, with the magnitude of risk increasing two and a half times after six hours, and a relative risk of 4.75 times when the usage was more than four hours per day (Jamaludin et al., 2025) and eight hours per day (Saeed[1] et al., n.d.). The exposure patterns were significantly stricter in the post-pandemic learning, as daily use more than five hours increased to 30 and to 88 in some cohorts (Eldo et al., 2024).

But the literature also indicates that continuous use, as opposed to cumulative daily hours, can have stronger predictive value (Alkousheh et al., 2025c), duration is not independently significant after ergonomic adjustment (Mowatt et al., 2018; Sonya Arshad et al., 2019). This subtlety emphasizes the significance of the behavioral and ergonomic spheres in Figure 3, which suggests that qualitative exposure features balance the quantitative risk. Modifiable determinants that were regularly used in the development of symptoms were the ergonomic and environmental determinants. The proximity to the visuals, an incorrect screen size, forward slope positioning, exposure to glare, visual contrast discrepancy, and a lack of lighting were commonly linked to increased prevalence of symptoms (Altalhi et al., 2020; Fatima et al., 2024b; Gadain Hassan, 2023; Yuan et al., 2022). Placing screens higher than the eye level enhances the exposure of the ocular surface and tear evaporation and use of low-light devices amplifies demand of contrast and visual stress. Accommodative and vergence load is also increased by hardware features, such as small font size, poor resolution, and low refresh rates (Alsaad et al., 2023; Kanwal & Khalil, 2024). A combination of these determinants highlights the fact that the emergence of DES is the result of the interaction of environmental configuration and physiological vulnerability and not screen time itself.

Nevertheless, although relationships are strong, critical analysis shows that there are limitations in the methodology. Dominance of cross-sectional designs impairs causal inference and use of self-reported questionnaires creates the effect of recall and reporting bias. Diagnostic heterogeneity: Differences in the definition and symptom threshold make it difficult to compare studies across studies. In addition among the few studies, only a limited number of studies included detailed ophthalmic examinations or long-term follow-ups, limiting knowledge on the long-term outcomes of the ocular surface or refractive operations.

There is still a paucity of interventional evidence, and the randomized controlled trials of ergonomic correction, structured breaks, artificial tear supplementation, or display modification are not enough. Longitudinal cohort studies should therefore be given more emphasis in the future research in elucidating the chronic effect, randomized controlled trials across the research to test the preventive measures and the objective biomarkers like blink rate monitoring, tear film analysis and integrating the accommodation facility tests. The exposure quantification and behavioral feedback in real time can be offered through technological developments such as eye-tracking systems and wearable posture sensors. Further comparability and meta-analytic precision would be facilitated by development of standardized international descriptive criteria of DES.

The implementation plans must indicate the integrated framework of Figure 3 with the aim of achieving a behavior change, ergonomic optimization, and environmental change in parallel. Regular breaks, proper viewing distance, positioning the screen a little bit below the eye level, matching luminance, and reducing glare are all the areas of intervention that have consistent evidence. Risk could also be reduced through institutional investment in adjustable ergonomic chairs, sensitization and regular vision checking. With the digital learning now extended globally, the management of such an issue requires a combined, multidisciplinary strategy involving ophthalmology, ergonomics, public health, and educational policy to minimize the visual fatigue load at the expense of digital learning benefits.

5. Conclusion

The review will summarize the current findings on visual fatigue and digital ergonomic hazards among university students who have to spend a long time at the screen due to the online learning process. The fact that 49 studies published post-2016 have been synthesized indicates that Computer Vision Syndrome (CVS) and Digital Eye Strain (DES) are very common and the reported rates of symptoms often surpass 60 percent and in some cohorts, they reach about 90 percent. The ocular symptoms of the disease, including dryness, burning eyes, blurred vision and eye strain, as well as extraocular symptoms, including headache and musculoskeletal pain, display a stable and multifactorial load in geographical settings.

The results affirm that although long screen time (especially after 488 hours daily) is a major quantitative risk factor, qualitative determinants, such as viewing distance, screen positioning, lighting, posture, hardware, and break patterns, have a significant effect on the severity of symptoms. The predictive effect of continuous, uninterrupted use seems to be more important than the cumulative daily time, which focuses on the behavioral aspect of risk. In addition, lower blink rate, tear-film instability and accommodative stress are identified as the major physiological mediators between digital exposure and the development of symptoms.

Although there is great associative evidence, cross-sectional design and the use of self-reported information are some of the methodological constraints in which causal inference and long-term knowledge are constrained. The lack of standard sets of diagnosis and interventional trials also demonstrates the necessity of longitudinal and experimental studies.

Altogether, visual fatigue in students studying at universities is a serious but adjustable work-related health issue in online learning. The key elements needed to support sustainable, health conscious screen-based learning ecosystems in higher education are institutional ergonomic policies, organized visual hygiene programs and evidence-based environmental optimization strategies.

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Biographies

Nayan Debnath Pranta is an undergraduate student in the Department of Industrial and Production Engineering at Shahjalal University of Science and Technology (SUST), Sylhet-3114, Bangladesh. His research interests include Human Factors and Ergonomics, Sustainable Manufacturing, Production System Optimization, and the applications of Machine Learning and Artificial Intelligence in industrial processes. He is focused on building strong analytical and technical skills relevant to modern manufacturing and industrial system design.

Nilufa Yeasmin is an undergraduate student in the Department of Industrial and Production Engineering at Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh. Her research interests include Human Factors &

Ergonomics, Production System Optimization, Supply Chain Management, Lean Manufacturing, and Quality Management. She is currently involved in research projects under Professor Dr. Mohammad Iqbal in the Department of Industrial and Production Engineering at SUST. She aims to contribute to developing sustainable and efficient manufacturing systems through human-centered and data-informed approaches.

Arnab Laskar is an undergraduate student in the Department of Industrial and Production Engineering at Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh. His research interests include Human Factors & Ergonomics, Organizational Behavior, Supply Chain Management, Quality Control Management, Machine Learning, and Industry 4.0. He is currently involved in research projects under Professor Dr. Mohammad Iqbal in the Department of Industrial and Production Engineering at SUST. He is particularly motivated to work at the intersection of intelligent manufacturing systems and ergonomic, human-centered design.

Professor Dr. Mohammad Iqbal is the Vice-Chancellor of North East University Bangladesh and a founding member of the Department of Industrial and Production Engineering at Shahjalal University of Science and Technology (SUST). He brings over 30 years of experience in teaching, research, and industry. He earned his B.Tech in Mechanical Engineering from Sri Venkateshwara University (1989), an M.Sc. in Industrial and Production Engineering from Bangladesh University of Engineering and Technology (BUET) (1993), and a Ph.D. from Dublin City University (2000). In 2018, he served as a Visiting Research Scholar at Texas A&M University. His research interests include virtual reality, ergonomics, industrial safety, supply chain management, renewable energy, and climate change. Professor Iqbal has published over 100 scientific articles and co-authored three engineering books. He is the President of the Ergonomics Society of Bangladesh and serves as Director of the SUST Research Ethics Board. Throughout his career, he has led several national research projects and has received multiple national and international awards in recognition of his contributions.

Professor Dr. Salma Akhter is a faculty member of the Chemical Engineering and Polymer Science department at SUST with over 20 years of academic and research experience. She earned her B.Sc. (1996) and Ph.D. (2012) from BUET and completed her M.Engg. at Dublin City University in 2000. She was a Visiting Research Scholar at Texas A&M University in 2018 and previously served as Head of her department (2016–2019). Her research areas include biofuel, process safety, waste management, renewable energy, and biochemical engineering. Professor Salma has over 25 publications in international journals and conferences. She serves as Chairman of the Chemical Engineering Division of IEB, Bangladesh, and Director of SUST's IQAC Center. She is also involved in national technical bodies and works as an expert for several gas fields in Bangladesh.