Universal Journal of Public Health 12(5): 1007-1014, 2024 http://www.hrpub.org
DOI: 10.13189/ujph.2024.120524

Enhancing Ergonomics in Digital Learning Environments: Addressing Health, Safety, and Environmental Sustainability

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Received July 18, 2024; Revised September 4, 2024; Accepted September 13, 2024

Cite This Paper in the Following Citation Styles

(a): *[1] Mohammad Aljaradin, Abdurrahman Almekhlafi, Athra Alkaabi , "Enhancing Ergonomics in Digital Learning Environments: Addressing Health, Safety, and Environmental Sustainability," Universal Journal of Public Health, Vol. 12, No. 5, pp. 1007 - 1014, 2024. DOI: 10.13189/ujph.2024.120524.*

(b): *Mohammad Aljaradin, Abdurrahman Almekhlafi, Athra Alkaabi, (2024). Enhancing Ergonomics in Digital Learning Environments: Addressing Health, Safety, and Environmental Sustainability. Universal Journal of Public Health, 12(5), 1007 - 1014. DOI: 10.13189/ujph.2024.120524.*

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Abstract With the increasing reliance on laptops and digital devices, Computer Vision Syndrome (CVS) has become a significant health concern for students. This study investigates the prevalence of CVS among cycle 3 students (secondary level comprising grades 9 to 12) at a public school in Sharjah, United Arab Emirates, using the validated CVS-Q web-based questionnaire to evaluate its impact on students' health, safety, and academic performance. Our findings reveal that 64% of the students suffer from CVS, with 51 out of 80 diagnosed with the condition. Common symptoms reported include headaches, burning eyes, excessive tearing, and decreased visual acuity. The study highlights the profound effect of CVS on students and emphasizes the urgent need for ergonomic improvements in digital learning environments. It provides empirical evidence on the prevalence of CVS and offers practical recommendations for enhancing digital learning ergonomics. Immediate intervention is necessary to redesign these environments to be more ergonomic and sustainable. Key recommendations include limiting laptop usage duration, optimizing ergonomic setups, using protective eyewear and screen filters, and encouraging regular eye exams. These measures can alleviate the adverse effects of prolonged digital device usage, thereby improving students' health and safety. Furthermore, promoting ergonomic practices supports environmental sustainability by fostering the design and use of energy-efficient and health-conscious digital devices. This study underscores the critical need for schools to implement comprehensive ergonomic strategies to support students' health, safety, and academic success in the digital age.

Keywords Computer Vision Syndrome, Ergonomics, Student Health, Visual Symptoms, Educational Impact

1. Introduction

Display technologies undeniably transformed people's lives; however, there is an alarmingly high incidence of significant vision problems linked to prolonged utilization of such technology [1]. The surge in vision issues and symptoms stemming from the extended use of digital screens has been coined Computer Vision Syndrome (CVS). Numerous studies often rely on the definition provided by the American Optometric Association (AOA) [2]; CVS is a cluster of eye and vision disorders triggered by continuous engagement with digital devices, also known as digital eye strain (DES). CVS symptoms include headaches, eye discomfort, dryness, redness, heaviness, and watering. The severity of these symptoms often increases with the length of time spent in front of a digital screen.

Reddy et al. [3] conducted a study on a college student population and uncovered that 90% of their subjects exhibited symptoms of CVS, particularly prominent in those who spent over two hours daily on a computer. Their findings highlighted headaches as the most discomforting symptom (19.7%), closely followed by eye strain (16.4%). Conversely, an investigation focused on university students in Ajman, UAE, discovered that the most prevalent CVS symptom among participants was a sensation of burning in the eyes (54.8%) [4]. Another study indicated that nearly 95% of the examined group experienced CVS, with tearing eyes being the foremost common symptom (59%), and 55.5% of the sample reported utilizing digital devices for over six hours each day [5].

Al Rashidi and Alhumaidan's study [1] identified eye redness and burning as the prevailing symptoms, with 72% of participants reporting acute symptoms and the remaining experiencing chronic issues. As demonstrated by the studies discussed, the dominant symptom and the duration of CVS symptoms seem to differ across various investigations. However, the common thread among these diverse study populations is the prevalence of CVS, exceeding 70% in most cases, thus highlighting the elevated occurrence of this syndrome.

The adoption of computer-based learning among children and students of various age groups has steadily risen, driven by the perception that it offers a superior alternative to traditional teaching methods [1]. A pivotal step was taken in 2012 with the launch of the Mohammed bin Rashid Smart Learning Program in the United Arab Emirates, which aimed at elevating smart learning practices within public schools. This initiative encompassed integrating smart courses across all schools, distributing devices to students, and establishing 4G networks in public educational institutions.

The program was fully implemented in 2019 and further supported by the Ministry of Education (MOE) [6] by introducing several platforms to advance smart education in schools. However, this technological shift has brought about concerns regarding the potential risk of CVS due to extended computer or laptop usage while studying.

This issue is a distinct environmental concern, particularly concerning the well-being and safety of individuals, especially those who find themselves compelled to engage extensively with digital screens for work or education. Within this context, the UAE government and the Ministries of Health and Education have undertaken substantial efforts to foster a health-conscious and secure environment for children, particularly within school settings.

CVS is a latent threat within this landscape, which can adversely impact students' health and safety. With the integration of smart learning methodologies into the UAE's educational framework, students' susceptibility to developing computer vision syndrome has heightened.

Rosenfield [7] extensively illustrates the repercussions of CVS on individuals who heavily utilize digital screens, including discomfort, vision-related health issues, diminished productivity, and an upsurge in work-related errors. An additional study underscores that while most of these symptoms are transitory, they can manifest frequently and chronically, potentially resulting in economic consequences for individuals relying heavily on digital screens [8].

This narrative particularly resonates with students, as CVS has the potential to impact their health and academic performance due to extended periods of laptop usage for studying and engaging with educational platforms. After several searches in different search engines, almost no published study in the UAE focused on measuring the CVS prevalence among school students after implementing smart learning /education in Sharjah. Even globally, few studies have discussed the CVS of school students who use laptops for learning.

Also, there were very few recommendations and measures taken by the Ministry of Education, Ministry of Health, and school staff to seek to reduce the effect of the prolonged use of laptops on students. These stakeholders (including parents) must take proper steps to prevent or reduce the risk of the prevalence of CVS among students. The results of this study provide evidence to stakeholders of the importance of looking into this issue and will provide measures to be taken by the relevant stakeholders.

2. Objectives

The primary aim of this study is to explore the prevalence of CVS among students in a school in Sharjah, where laptops are extensively used as educational tools. Given the increasing reliance on digital technology for learning, it is crucial to understand the extent of CVS among students. This research seeks to provide a detailed assessment of CVS symptoms and their correlation with laptop usage.

Specifically, the study aims to determine the extent of CVS among cycle 3 laptop users and identify the most effective strategies for managing and preventing CVS symptoms in this population. By shedding light on these aspects, the research will contribute to a better understanding of CVS and its impact on students, ultimately guiding the development of practical solutions to mitigate its effects.

3. Materials and Methods

Most of the studies regarding measuring the CVS symptoms used questionnaires as a tool to assess the presence and the severity of CVS conditions. Some studies used objective evaluations of parameters such as critical flicker–fusion frequency, accommodative function, and blink rate and completeness. Questionnaires are more cost-effective, simple, and accessible than objective evaluations.

Also, objective evaluations cannot measure all CVS parameters with a single assessment, so usually in the studies, it is combined with questionnaires.

In their study, Chi and Lin [9] declared that survey questions are simple to administer and can be more sensitive than objective assessments in some cases. In addition, questionnaires have been utilized to contribute to the validity of objective assessments of visual strain [9]. For example, Gammoh [5] used a qualified clinician to conduct a regular eye examination and review each participant's health and ocular status in addition to the questionnaire tool.

However, the questionnaire tool has a primary weakness in some of the previous CVS studies. The weakness is the adoption of unvalidated ad hoc questionnaires to evaluate CVS, which in several circumstances did not offer insight into the syndrome, but instead concentrated on separate specific symptoms with inaccurate CVS definitions [10]. For example, Reddy et al. [3] considered that the student was diagnosed with CVS if he or she had at least one symptom while using the computer. Moreover, it did not show the full scope of the syndrome as in the CVS definitions, and the symptoms might not directly relate to the syndrome. Fortunately, there are recent studies that developed a validated and reliable questionnaire.

For example, researchers [4, 5] used validated questionnaires to assess the CVS in their study population. A study done by Segu í Mdel et al. [11] resulted in the development of the first validated questionnaire for measuring 16 ocular and visual symptoms associated with computer use in the working population using the Rasch model.

The answers to the questions aid in assessing the severity of each symptom and the severity of symptoms (CVS score). Workers with a score of ≥ 6 suffer CVS. The questionnaire has good psychometric characteristics, seeking to make it a viable and reliable instrument for surveilling the visual health of people who use the screens [11].

In contrast, other questionnaires measure the CVS, such as the Visual Ergonomics Risk Assessment Approach (VERAM), a recently created and verified instrument for evaluating occupational visual ergonomics. VRAM comprises a questionnaire and an objective assessment that studies many factors. This method is comprehensive and time-consuming compared to the Segu í Mdel et al. [11] CSV questionnaire (CVS-Q) which is easier and quicker [12].

The CVS-Q is widely expected and used because it was designed with broad consensus among specialists in the field. This study might help to increase the focus on measuring the CVS in school students since most of the CVS studies were done among university students or workers. Ganne et al. [13] recommend further studies to evaluate ocular strain in children (under 18) since they represent a significantly at-risk category. As this study was for school students, the Segu í Mdel et al. [11] CVS questionnaire (CVS-Q) was used because it is easy, simple, and does not require much time to answer the questionnaire.

Additionally, several studies used CVS-Q to assess the CVS prevalence among workers and college students and thus help to support this study's results. Moreover, performing the clinical-visual related tests (objective evaluation) was impossible because of the COVID-19 precautionary measures. Hence, using a web-based questionnaire was safer for the students during the Covid-19 pandemic. So, the CVS-Q was more visible and accessible and conforms to the time frame of this study.

The study population consisted of a carefully selected sample of 80 female students from cycle 3 (previously Secondary Level 9-12 Grades), each enrolled in a school situated in Sharjah.

Alsharjah is one of the 7 Emirates of the United Arab Emirates. Additionally, Al Sharjah refers to the city capital of Al Sharjah Emirate. The educational system in Alsharjah is the same as the other 6 Emirates categorizing education into three cycles basic, intermediate, and secondary.

Participants were randomly chosen from student name lists. Certain exclusion criteria were applied to uphold the integrity of the study's findings. Specifically, students outside the designated age range were excluded, as were individuals categorized as "people of determination" who may use specialized devices suited to their unique health circumstances. Furthermore, participants with chronic eye problems or diseases were excluded based on their documented health records.

To facilitate this, a screening question was incorporated within the study questionnaire to identify individuals falling within these excluded categories. Upon collecting all responses to the questionnaire from the participating students, the subsequent step involved rigorous statistical analysis.

This study utilized a web-based validated questionnaire that was distributed to study participants through their email accounts. Class teachers were responsible for sending, following up, and receiving the responses to the questionnaire.

The participants' age span ranged between 14 and 18 years. Participants came from a diverse group with a variation in their sociodemographic background. Although most participants were Emirati, the sample included some students from other nationalities. Arabic was the language of instruction in public schools in Sharjah. The socioeconomic status of students is almost the same with an average income and equal access to technology.

The computation of the CVS score for each student was conducted utilizing a Microsoft Excel spreadsheet. A diagnosis of computer vision syndrome was assigned to a student if the cumulative value of their 16 symptoms equaled to or exceeded 6.

Furthermore, the prevalence of the 16 symptoms covered by the CVS-Q questionnaire was determined using percentage calculations. Descriptive analysis was then undertaken, primarily relying on frequency and relative

frequency, to provide insights into student participants' most observed symptoms. The cohort under study for our research comprises female students in Cycle 3 of a school located in Sharjah. Notably, students falling outside the designated age range, individuals categorized as people of determination, or those grappling with chronic eye issues or diseases were excluded from the study.

The sampling frame employed encompasses an updated list of students from grades 9 to 12 registered for the second semester at the above-mentioned school in Sharjah. This rigorous selection approach ensures the authenticity and reliability of our research findings by focusing on a defined and appropriate study group.

The CVS score for each student was computed based on the cumulative value of their 16 symptoms, with a score of 6 or higher indicating a diagnosis of CVS. A descriptive analysis was conducted to determine the prevalence of symptoms and provide insights into the most observed symptoms among the students.

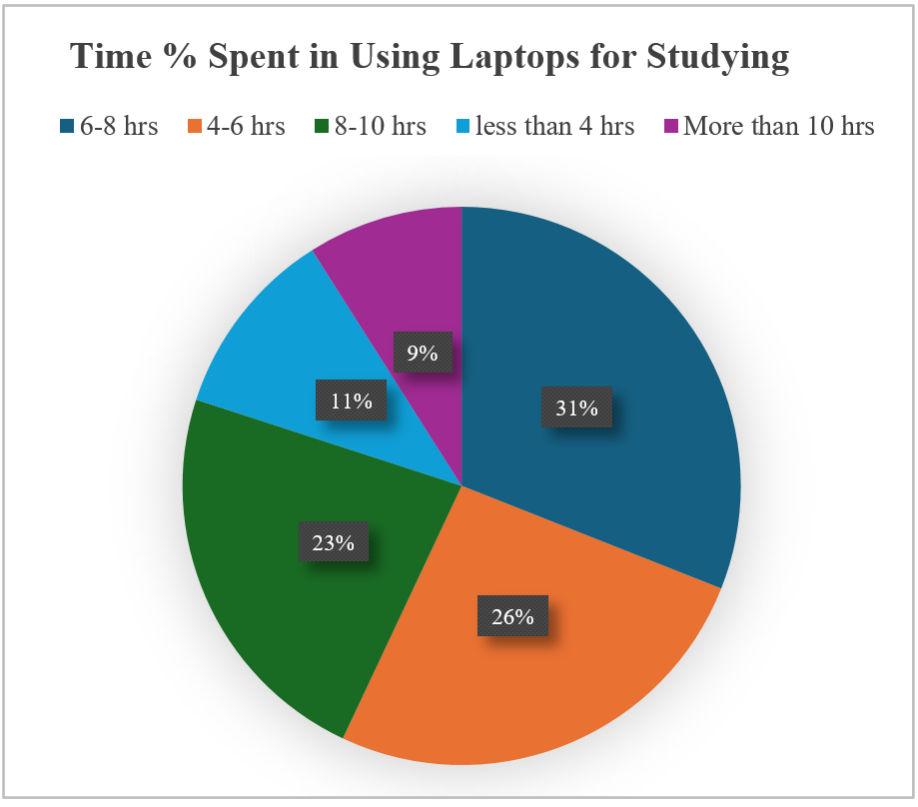
The study encompassed various variables representing different facets of the student's experiences and responses. These variables included the number of hours spent using laptops (ordinal scale), the continuity of laptop use (nominal scale), knowledge about CVS (yes/no question, nominal scale), awareness of the 20/20/20 rule (yes/no question, nominal scale), presence of ocular diseases (yes/no question, nominal scale), use of medical glasses (yes/no question, nominal scale), and the frequency and intensity of 15 CVS symptoms (ordinal scale). Permission was sought from the school principal to enter classrooms during instructional periods, ensuring a smooth data collection process.

For students who could not attend classes due to distance learning or COVID-19-related circumstances, Microsoft Teams was used to facilitate their participation. In close coordination with the students, we secured informed consent. Our presence during the questionnaire completion process, alongside the class teachers, helped maintain an organized and supportive atmosphere.

4. Results

The results indicate that among the participants, 68 students adopted an intermittent usage pattern, whereas 12 students consistently utilized laptops. A noteworthy 69% of students reported not having any prevalent eye diseases, while 31% acknowledged the presence of such conditions.

Similarly, a significant majority, accounting for 74%, affirmed not using corrective eyewear, while the remaining 26% relied on glasses to address vision-related issues. Interestingly, when asked about their familiarity with CVS and awareness of the 20/20/20 rule, none of the students answered affirmatively, see Figure 1.



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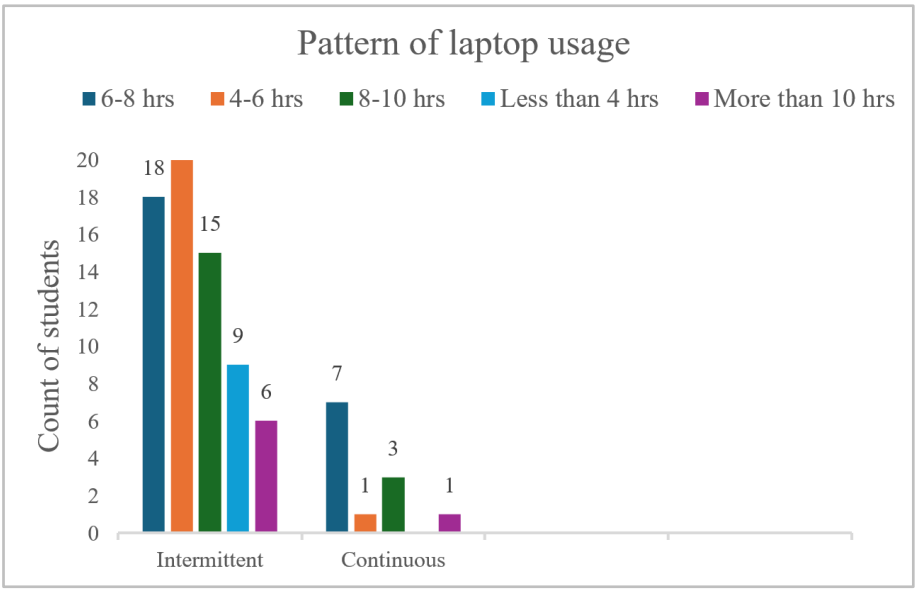

B

Figure 1. Duration of Laptop Usage. (A) Hours spent using laptops for studying; (B) pattern of laptop usage, distinguishing between intermittent and continuous use

Figure 1 A illustrates the distribution of hours spent using laptops for studying among students. The largest segment, comprising 31% of students, spends between 6-8 hours on their laptops. This is followed by 26% of students who use their laptops for 4-6 hours, 23% for 8-10 hours, 11% for less than 4 hours, and a small fraction (9%) spending more than 10 hours on their laptops.

Figure 1 B illustrates the pattern of laptop usage, distinguishing between intermittent and continuous use.

Among students with intermittent laptop use, 20 students fall into the 4-6 hours category, 18 students in the 6-8 hours category, and 15 in the less than 4 hours category. Fewer students report intermittent use for 8-10 hours (9 students) and more than 10 hours (1 student). In contrast, continuous laptop use shows a different pattern, with 7 students using laptops for 8-10 hours, 6 for 6-8 hours, and 3 for 4-6 hours. Very few students report continuous usage for more than 10 hours (1 student) or less than 4 hours (1 student).

The results indicated that 51 out of the 80 students examined exhibited CVS symptoms, as their scores met or exceeded the designated threshold of 6, leading to their diagnosis with CVS. Conversely, the remaining 29 students reported scores below 6, indicating the absence of a CVS diagnosis. Thus, the prevalence of CVS among the study's sample stood at 63.75%. Table 1 displays the frequency and relative frequency of distinct CVS symptoms. Headaches emerged as the most prevalent symptom among participants, affecting 61% of the sample, while symptoms like increased sensitivity to light and difficulties focusing on near vision were relatively less common, impacting around 31% of participants.

The high occurrence of headaches (61%) suggests that students may be experiencing considerable stress and strain on their eyes and surrounding muscles, potentially resulting from extended periods of screen time. The reported burning sensation (58%) and tearing (55%) indicate potential discomfort and irritation, likely associated with prolonged exposure to digital screens. Itching (54%) and excessive blinking (53%) further indicate the strain on the eyes, possibly caused by insufficient breaks or improper screen ergonomics.

Table 1. The Frequency and Relative Percentages of the CVS Symptoms

CVS Symptom	Frequency	Relative Percentage
Headache	49	61%
Burning	46	58%
Tearing	44	55%
Itching	43	54%
Excessive blinking	42	53%
Eye pain	42	53%
Dryness	40	49%
Feeling that eyesight is worsening	39	49%
Heavy eyelids	38	48%
Colored halos around objects	37	46%
The feeling of a foreign body	36	45%
Double vision	31	39%
Blurred vision	31	39%
Eye redness	26	33%
Difficulty focusing on near vision	25	31%
Increased sensitivity to light	25	31%

These findings suggest that students experience various

discomforting symptoms associated with prolonged computer use, highlighting the need for interventions to promote eye comfort and prevent CVS. Results also showed that combating CVS among students necessitates a comprehensive strategy, including environmental, behavioral, and lifestyle interventions and additional supportive measures.

Key environmental strategies involve optimizing the study space to minimize glare with appropriate lighting, adjusting digital screen configurations to ensure comfortable brightness and contrast levels, and ensuring proper desk and chair alignment so that screens are at eye level and at a correct distance. Adopting regular visual breaks, such as adhering to the 20-20-20 rule, which entails taking a 20-second break to view something 20 feet away every 20 minutes, can alleviate eye strain. Regular eye exercises also play a crucial role in maintaining eye health.

Lifestyle modifications are vital, including adequate hydration, a nutrient-rich diet, sufficient rest, and restrained screen time, particularly before sleep. These changes can bolster overall eye well-being. Supplemental strategies to alleviate CVS encompass routine eye examinations, using artificial tears to combat dry eyes, proper eyelid care, and practicing relaxation techniques, such as yoga and meditation, to reduce stress levels that may contribute to CVS symptoms.

5. Discussion

The results of this study provide valuable insights into the patterns of laptop usage and the prevalence of CVS among students. The majority of students exhibit intermittent laptop usage patterns, with a significant portion using laptops for extended periods. The findings reveal a prevalent lack of awareness regarding CVS and the 20/20/20 rule, underscoring the need for educational interventions to promote eye health among students. The data indicate that a substantial proportion of students, 63.75%, exhibit symptoms of CVS, with headaches being the most common symptom, affecting 61% of participants.

This high prevalence of headaches suggests significant eye strain and stress, likely due to prolonged screen time without adequate breaks or ergonomic considerations. The frequent occurrence of other symptoms such as burning, tearing, itching, and excessive blinking further supports the notion that students are experiencing considerable eye discomfort. The study's findings highlight the importance of adopting comprehensive strategies to combat CVS.

Environmental adjustments, such as optimizing lighting and screen configurations, are crucial in minimizing glare and ensuring comfortable viewing conditions.

Behavioral interventions, including the promotion of the 20/20/20 rule and regular visual breaks, are essential in alleviating eye strain. Moreover, lifestyle modifications, such as maintaining adequate hydration, a nutrient-rich diet, and sufficient rest, play a vital role in supporting overall eye health. Supplemental strategies, such as routine eye examinations and the use of artificial tears, are also recommended to manage CVS symptoms effectively. Additionally, stress reduction techniques, such as yoga and meditation, can help mitigate the impact of stress on eye health. This study underscores the high prevalence of CVS symptoms among students, attributed to prolonged laptop usage without sufficient breaks or ergonomic adjustments.

The lack of awareness regarding CVS and preventive measures like the 20/20/20 rule further exacerbates the issue. To address CVS effectively, a multifaceted approach is necessary, encompassing environmental, behavioral, and lifestyle interventions, along with supportive measures such as regular eye care and stress management techniques.

Implementing these strategies can significantly improve eye comfort and overall well-being among students, reducing the prevalence and impact of CVS.

Educational institutions must raise awareness about CVS and promote healthy digital habits to ensure the ocular health of their students. This observation aligns with previous research, establishing a direct link between extended digital screen exposure and the increased prevalence of CVS symptoms, notably exceeding 4 hours daily [10]. While it is encouraging that 85% of students reported using laptops intermittently, suggesting potential breaks between sessions, the study's high prevalence of CVS, even among this group, highlights the complex and multifaceted nature of the syndrome.

This finding challenges the simplistic assumption that mere breaks are sufficient to mitigate CVS risk. Notably, prior research supports this observation, with studies like Al Rashidi and Alhumaidan [1] demonstrating a direct correlation between increasing screen time and the severity of CVS symptoms, regardless of intermittent breaks. This underscores the need for more comprehensive preventive strategies that address the duration, intensity, and nature of digital screen interaction.

A crucial revelation from this study is the stark lack of student awareness regarding CVS and the recommended 20/20/20 rule. None of the participants reported prior knowledge of either, highlighting a significant knowledge gap that likely hinders the implementation of preventive measures. This finding aligns with concerns raised by Gammoh [5], who emphasized the critical need to address the impact of digital devices on students' health and called for heightened awareness among stakeholders and decision-makers. Gammoh also highlighted the importance of the 20/20/20 rule in reducing digital-related eye strain, citing its simplicity and effectiveness.

However, as this study demonstrates, the effectiveness of the 20/20/20 rule hinges on raising awareness and educating students about its benefits. Bridging this knowledge gap through educational initiatives and awareness campaigns is essential to empowering students to take ownership of their eye health and mitigate the risks associated with prolonged exposure to digital screens.

In eye health and vision correction, this study uncovered

that 31% of students reported having eye diseases, and 26% utilized corrective glasses. While this study did not dig into the relationship between eye diseases and CVS, Rosenfield [7] has suggested that ocular conditions could contribute to CVS.

On the other hand, Cantó-Sancho et al. [10] found no significant relationship between wearing glasses and CVS. These factors warrant careful consideration in future studies to understand their potential influence on CVS development.

While several studies reported prevalence rates exceeding 70% [1, 4, 5, 8], this study found a prevalence of 64%. Possible reasons for this variance could be attributed to the relatively young age of the participants, potentially leading to an underestimation of symptom frequency and severity compared to university students and workers. Despite this discrepancy, the core objective of this study remains consistent – highlighting a substantial prevalence of CVS among students.

The analysis of CVS symptoms further contributes to understanding the manifestation of the syndrome. Headaches emerged as the most reported symptom, a trend in similar university-based studies [10]. Other prevalent symptoms included burning eyes, tearing eyes, itching eyes, excessive blinking, eye pain, and dryness. Nearly half of the sample reported worsening eyesight, implying that prolonged laptop usage might affect students' vision. This result surpasses Gammoh's [4] findings, suggesting potential variations in the impact of laptop usage across different populations. Similarly, Alchivona et al. [14] pointed out that computers have damaging effects on children and adolescents' health. These effects have increased dramatically due to increased use of screen time.

6. Conclusions

To enhance ergonomics in digital learning environments and address health, safety, and environmental sustainability, it is imperative to review and limit compulsory screen time associated with smart learning initiatives to safeguard students' visual health. Providing high-quality screens and protective accessories, alongside developing software that tracks and enforces eye health best practices such as regular breaks, is essential. Collaboration with the Ministry of Health is necessary to disseminate information on identifying and preventing CVS while integrating CVS considerations into school health programs through safety departments and regular vision screenings by school nurses. Educators must apply screen time best practices by incorporating teaching methods that reduce screen exposure, promote breaks, encourage physical activities, and maintain proper hydration. Parental involvement in monitoring screen time, ensuring balanced activities, and regular eye care is critical. Future research should pair the CVS-Q questionnaire with actual eye examinations for more precise findings and expand the scope to include varied ages and device usage patterns. Evaluating school-based factors such as furniture ergonomics, illumination conditions, and screen quality specifications is vital for developing targeted interventions. Collaboration with ophthalmologists and health experts will facilitate the creation of age-specific guidelines that reinforce a comprehensive approach to CVS prevention and support environmental sustainability. Integrating these measures will not only protect students' visual health and promote overall well-being but also support the broader objective of creating sustainable digital learning environments.

By proactively addressing the challenges posed by extended screen time, we can lay the groundwork for a healthier future where online learning is optimized for long-term student success. These initiatives will ensure that as digital education continues to evolve and expand, it does so in a way that minimizes health risks while enhancing the learning experience, making it more sustainable and effective for future generations [15].

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