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The Effect of Computer Vision Syndrome on Sleep Quality in Users of Digital Displays: A Systematic Review

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Abstract

Background: The increased use of digital devices has led to a rise in computer vision syndrome (CVS), particularly with remote work and online learning. Prolonged screen use also negatively impacts sleep quality. This paper aims to review existing research on the association between CVS and sleep quality in digital screen users.

Material and Method: The study conducted a literature search across various databases using specified terms to find articles on the association between computer vision syndrome (CVS) and sleep quality among digital device users. The search was limited to articles published between 1900 and 2023 and followed the PRISMA guidelines for systematic reviews. Scopus, PubMed, Web of Science, and Google Scholar databases were searched for relevant articles. The inclusion criteria involved original research concurrently examining sleep quality and CVS, published in English or Persian language scientific journals.

Results: The eligibility of the entire texts of 52 articles was assessed, resulting in 17 cross-sectional studies that met the inclusion criteria for this review. A significant correlation exists between eye discomfort and poor sleep quality ($p<0.05$), with individuals experiencing CVS frequently reporting disrupted sleep. Moreover, reduced sleep duration is significantly associated with the severity of eye problems ($p= 0.001$). Furthermore, the time spent using digital screens is also related to CVS and sleep quality.

Conclusions: Excessive electronic device use has caused an increase in Computer Vision Syndrome (CVS) and worsened sleep quality due to prolonged screen time and exposure to blue light. To mitigate these issues, limiting screen time and using protective measures to reduce blue light exposure is crucial, as they can affect cognitive and physical performance.

Keywords: Vision Disorders, Digital Screens, Sleep Quality, Systematic Review.

Introduction

Computers and displays have become an indispensable aspect of daily activities for individuals. They have evolved into essential devices for all areas of life, and currently, their extensive utilization as an instrument for teaching and learning is prevalent in schools and universities (1, 2).

The COVID-19 pandemic has led to a rapid shift towards digitalization worldwide, resulting in a significant increase in the number of users of digital

display devices. This change in perspective has been driven by the guidelines for social distancing by the World Health Organization, which in turn have prompted the development of various digital innovations such as teleconferencing and online commercial platforms (3, 4). The pandemic has also significantly impacted the education sector, leading most countries to adopt online classes as a preventive measure (5). Consequently, individuals affected by the pandemic have shifted most of their work activities online, resulting in prolonged usage of computers and mobile phones for online purposes (5, 6).

The increased use of cell phones, including Smartphone, has raised concerns about potential health risks, as several studies have linked cell phone usage with health outcomes such as malignant melanoma of the eyes, headaches, and brain tumors (7). Moreover, prolonged and continuous use of computers and digital screens has resulted in a condition known as CVS. The American Optometric Association (AOA) defines CVS as a collection of vision and eye problems experienced during or after using digital devices (8). Common symptoms of CVS include headaches, blurred vision, double vision, eye fatigue, watery eyes, light sensitivity, and dry eyes (9).

CVS is widely regarded as one of the most significant occupational hazards of the 21st century, and its symptoms impact a significant proportion of computer users, depending on the studied population (7, 9-11). The prevalence of CVS varies based on the group studied, and the methods used to evaluate CVS range from 25% to over 90%. Approximately 60 million individuals who utilize computers around the globe are afflicted with Computer Vision Syndrome (CVS), and nearly one million additional cases are identified annually (5, 9, 12, 13).

The symptoms of CVS can be attributed to ocular causes, such as uncorrected refractive errors and visual abnormalities. Additionally, they may arise from ergonomic causes, such as poor sitting position, unsuitable screen distance and angle, poor display resolution and contrast, insufficient brightness, and an imbalance between the display and environmental lighting (5, 9, 14-16).

The AOA recommends limiting the continuous use of digital devices to two hours per day to prevent eye and vision problems. The protracted utilization of these instruments not solely engenders tension in the visual system but can also induce musculoskeletal compression and disturbance of the circadian cycle. (17).

Long-term exposure to electronic devices such as computer screens and mobile phones can disrupt normal sleep patterns, leading to insufficient sleep, poor performance at work and school, reduced productivity, lack of energy, increased risk of weight gain, and depression (9, 18, 19). Numerous studies have shown that exposure to artificial light at night can negatively impact sleep quality and daytime alertness. Additionally, the adverse effects of disrupted sleep quality and alertness can manifest physically as neck and eye tension, eye fatigue, headache, and impaired cognitive function (20 -24).

Most studies have focused on investigating the impact of screen use on eye health. However, some studies have explored the relationship between sleep quality and the occurrence of symptoms related to CVS. Notably, no comprehensive review has been conducted on the connection between CVS and sleep quality. So, this study aims to review the existing literature on the relationship between CVS and sleep quality and summarize recent findings in this area.

Materials and Methods

A systematic review is a method used to address specific research questions by comprehensively identifying and summarizing all relevant studies in a given topic area, thereby providing an up-to-date synthesis of the existing knowledge.

The systematic review outlined in this paper adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Search Strategy: The Scopus, PubMed, Web of Science, and Google Scholar databases were searched for relevant articles, and a combination of keywords such as sleep, sleep disorders, sleep quality, insomnia, awakening, asleep, nightmare, dreams, sleep deprivation, sleep loss, circadian, computer vision syndrome, and CVS were used. The electronic database searches were executed on May 5, 2023, encompassing publications from 1900 to 2023 to ensure the inclusion of potentially valuable studies. Title, abstract, and keywords were the fields considered in the queries. Furthermore, we limited our search to documents available in English and Persian. Table 1 indicates the search strategy in each of the databases. Search in Google Scholar was performed using its Advanced Search Feature.

Table 1. Search queries in each of the databases

Database	Search query
PubMed	("sleep"[Title/Abstract] OR "sleep disorders"[Title/Abstract] OR "sleep quality"[Title/Abstract] OR "Insomnia"[Title/Abstract] OR "awakening"[Title/Abstract] OR "asleep"[Title/Abstract] OR "nightmare"[Title/Abstract] OR "dreams"[Title/Abstract] OR "sleep loss"[Title/Abstract] OR "sleep deprivation"[Title/Abstract] OR "circadian"[Title/Abstract]) AND ("computer vision syndrome"[Title/Abstract] OR "cvs"[Title/Abstract])
Scopus	(TITLE-ABS-KEY (sleep) OR TITLE-ABS-KEY (sleep quality) OR TITLE-ABS-KEY (sleep disorders) OR TITLE-ABS-KEY (insomnia) OR TITLE-ABS-KEY (awakening) OR TITLE-ABS-KEY (asleep) OR TITLE-ABS-KEY (circadian) OR TITLE-ABS-KEY (nightmare) OR TITLE-ABS-KEY (dreams) OR TITLE-ABS-KEY (sleep loss) OR TITLE-ABS-KEY (sleep deprivation)) AND (TITLE-ABS-KEY (cvs) OR TITLE-ABS-KEY (computer AND vision AND syndrome))
Web of science	(TS= (cvs) OR TS= (computer vision syndrome)) AND (TS= (sleep) OR TS= (sleep quality) OR TS= (sleep disorders) OR TS= (insomnia) OR TS= (awakening) OR TS= (asleep) OR TS= (circadian) OR TS= (nightmare) OR TS= (dreams) OR TS= (sleep loss) OR TS= (sleep deprivation))

Eligibility Criteria: To evaluate the pertinence of each retrieved paper in addressing our research inquiries, we employed a set of inclusion criteria:

Original research that concurrently investigated both sleep quality and the occurrence of CVS, papers published in either English or Persian, and papers published in scientific journals.

Animal studies, studies not related to the research objective, systematic review and meta-analysis studies, theses, letters to editors, conference papers, and preprinted studies were excluded from this review.

Study Selection: Following the execution of database queries, we utilized Endnote® X8 to record references, and eliminate repeated records. Then, a manual review was conducted to eliminate any remaining duplicate entries further, creating a singular reference library.

We employed a multi-stage procedure to assess the papers in the initial database. This involved reviewing the titles, abstracts, and keywords, followed by thoroughly examining the full texts of selected papers. At each stage of the screening process, two authors independently evaluated the papers critically. Any documents selected by at least one reviewer were advanced to the next screening stage, taking an inclusive approach to reduce the likelihood of excluding pertinent papers. A third independent referee resolved any disagreements between the researchers.

In the final stage, we gathered the studies that met our inclusion criteria, which are the documents directly relevant to our research questions. To ensure complete confidence in their relevance, we thoroughly reviewed the full text of all articles initially identified as relevant. Subsequently, these selected articles were analyzed to explore the relationships between the variables of interest. Fig. 1 provides a concise overview of the intermediate selection process and the steps leading to the creation of the final database.

Results

Fig. 2 illustrates the process of article selection in this study. Initially, 1346 articles were obtained from various databases, with 345 duplicates. After screening the remaining articles based on title and abstract, 949 were excluded for being irrelevant or review articles. The eligibility of the entire texts of 52 remaining articles was assessed, resulting in 17 cross-sectional studies that met the inclusion criteria for this review. The total number of participants included in these studies was 36,192.

Fig. 1. Cloud of words presented in the complete texts of the articles

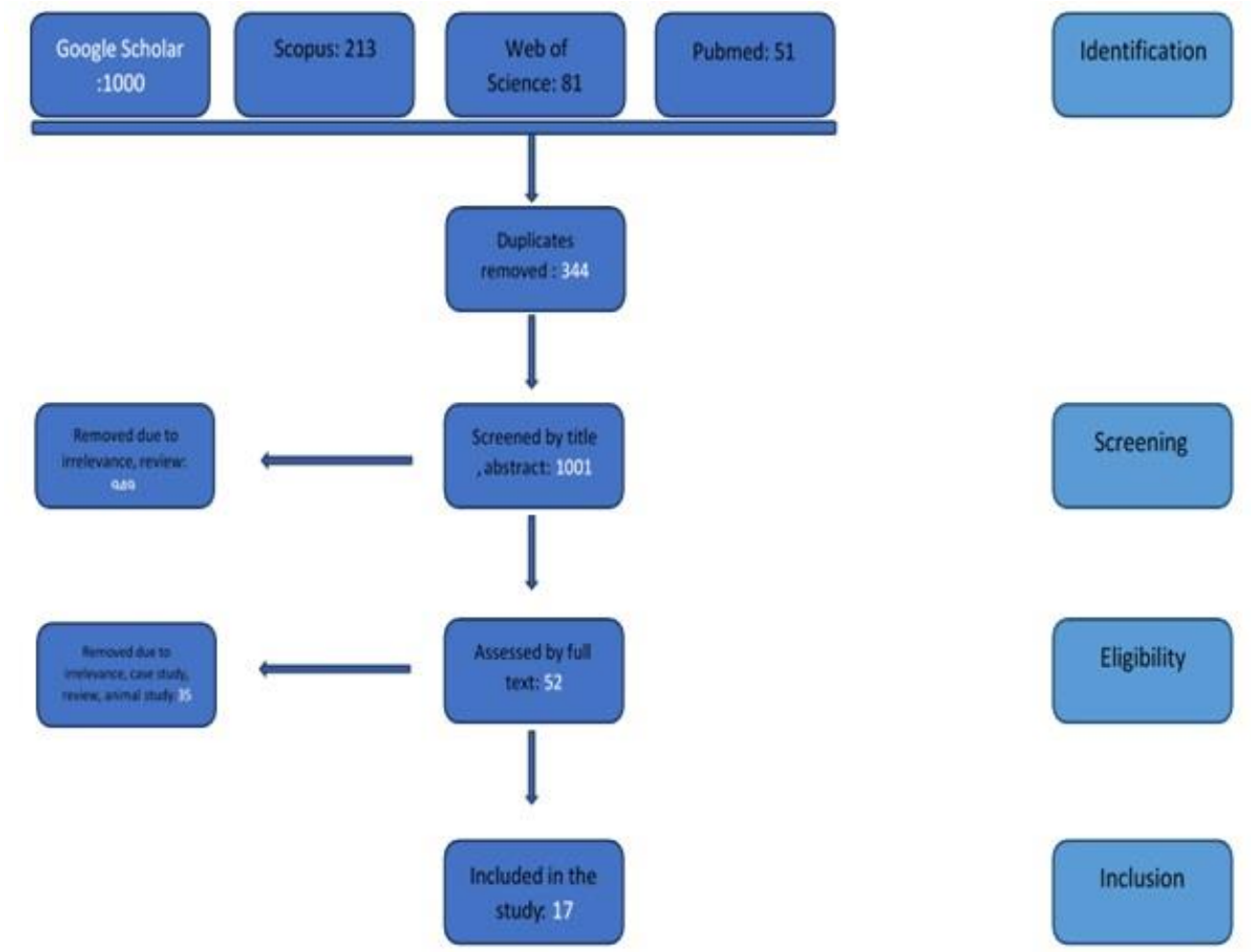

Fig. 2. Search Strategy

The temporal distribution of the studies showed that most of them were conducted in 2020 and later. It is worth noting that most of these studies were conducted in Asia and Africa, with 15 studies in Asia and 2 in Africa and Europe. Researchers from various countries have conducted these studies, with India having the highest number of studies (5). Regarding the study population, 12 studies were conducted among students, 4 among the general public, and 1 among health center employees.

Several indicators have been employed in assessing participants' sleep quality in the studies, with three of them relying on the Pittsburgh Questionnaire. The CVS questionnaire has been utilized in eleven studies to evaluate eye symptoms. Furthermore, six studies have utilized distinct questionnaires included in this review due to their association and overlap with CVS. The details of the studies analyzed in this review are presented in Table 2.

Fig. 3. Cloud of words presented in the complete texts of the articles

Table 2. Summary of the included papers

Author	Study design	Year	Country	Community	Sleep measurement tools/indices	Eye measurement tools	Sample size	Main Result
Roy et al.(5)	Cross-Sectional	2022	Bangladesh	Postsecondary Students	Insomnia	CVS questionnaire	917	Individuals with a family history of sleep problems have an increased risk of CVS.
Kim et al.(7)	Cross-Sectional	2015	South Korea	adolescent subjects	Sleep duration	self-reported ocular symptoms: vision blurring, redness, visual disturbance, secretion, inflammation, lacrimation and dryness	715	People who sleep less tend to have more eye issues.
Gupta et al.(51)	Cross-Sectional	2021	India	college‐going women	10‐item Mini Sleep Questionnaire to check the quality of sleep	Standard Patient Evaluation of Eye Dryness (SPEED)	547	Most women with dry eyes struggle with serious sleep problems.
Akowuah et al.(9)	Cross-Sectional	2021	Ghana	Undergraduate students	PSQI questionnaire	CVS questionnaire	391	The chi-square test revealed a significant association between CVS and sleep quality.
Ahmad et al.(8)	Cross-Sectional	2021	Saudi Arabia	health science students	PSQI questionnaire	CVS questionnaire	564	81.4 %(N = 459) had poor sleep quality 4.4% of the students did not have any CVS symptoms.
Patil et al.(2)	Cross-Sectional	2019	India	medical students	PSQI questionnaire	CVS questionnaire	500	All the components of the PSQI score, except components 1 and 6, had statistically significantly ($P < 0.05$) higher values in individuals with CVS than individuals without CVS.

Bahkir et al.(21)	Cross-Sectional	2020	India	individuals above 18 using digital devices	Sleep disturbances	CVS questionnaire	407	As screen time went up, the frequency and intensity of symptoms and sleep disturbances also statistically significantly increased.
Tsou et al.(30)	Cross-Sectional	2022	Taiwan	Health Care Workers	BSRS-5 Self-assessment sleep quality question	CVS questionnaire	945 + 1868	As visual display terminal (VDT) working times increased, so did the risk of eye discomfort, headaches, high job stress, and poor sleep quality. However, VDT working time was not associated with statistically significant differences in CVS, BSRS-5 score, burnout, overall health self-assessments, or sleep duration.
Liu et al.(32)	Cross-Sectional	2022	China	Medical students	the length of daily sleep	eye discomfort symptom questionnaire	686	The analysis showed that for every 1 h increase in the patients' total daily sleep time, their likelihood of developing eye discomfort symptoms decreased by 23%; The severity of eye discomfort symptom was significantly negatively related to the increased total sleep duration
Wangsan et al.(3)	Cross-Sectional	2022	Thailand	students studying in a virtual classroom	Sleep duration	CVS questionnaire	527	The study found that a lower sleeping duration is associated with CVS, and In the CVS group, the average sleep duration was shorter
Akiki et al.(54)	Cross-Sectional	2022	Lebanon	all digital device users	Lebanese Insomnia Scale (LIS-18)	CVS questionnaire	749	CVS was significantly associated with insomnia. Stress mediated the relationship between CVS and insomnia.

Al subai et al.(33)	Cross-Sectional	2018	Saudi Arabia	individuals visiting a shopping mall	Disturb sleep	CVS questionnaire	416	There is no significant relationship between disturbed sleep and CVS
Li et al(34)	Cross-Sectional	2021	China	8–20 years old students	Sleep time	CVS questionnaire	25781	As compared to their peers without asthenopia, those students with asthenopia tended to sleep less
Hesam et al(56)	Cross-Sectional	2013	Iran	graduate students	drowsiness	Low vision	70	30 % low vision Drowsiness: 17.86 out of 40
Cacodcar et al.(35)	Cross-sectional	2021	India	students	sleep disturbance	ocular symptoms	108	63% had sleep disturbance, and 76.9% of study subjects experienced Cvs symptoms.
Talens-Estarelles et al.(31)	Cross-sectional	2022	Spain	university students	hours of sleep	(1) Computer Vision Syndrome Questionnaire, (2) Ocular Surface Disease Index (OSDI), (3) 5-item Dry Eye Questionnaire (DEQ-5), (4) 8-item CL Dry Eye Questionnaire (CLDEQ-8)	851	(73.8%) were classified into the group with DES participants with DES slept fewer hours (P¼0.025)
Lakshmi et al(29)	Cross-sectional	2020	India	medical undergraduates	Insomnia Severity Index (ISI) questionnaire	Prevalidated questionnaire on symptoms of computer vision syndrome	150	70% of students have clinical insomnia of moderate severity. More than 70% of students had severe eye symptoms in some cases

Discussion

The widespread use of electronic devices has resulted in computer vision syndrome (CVS) emerging as a noteworthy health issue for individuals. In addition to its impact on ocular health, excessive use of digital screens has been found to affect other areas, such as sleep quality. The current investigation aims to extensively analyze existing scholarly literature to examine the relationship between Computer Vision Syndrome (CVS) and the quality of sleep experienced by individuals who use digital devices.

Numerous investigations have been conducted to assess CVS symptoms and sleep quality. A cross-sectional study conducted in Thailand aimed to determine the prevalence, characteristics, and associated factors of computer vision syndrome (CVS) among university students during the COVID-19 pandemic. The research revealed that the occurrence of CVS among the 527 participants was 81%, with increased screen time being suggested as the main cause. The study also found that female participants, those with atopic diseases, those with prior ocular symptoms, and those with astigmatism were more likely to develop CVS. The study suggests that students should use a desktop or laptop computer rather than a mobile phone, adjust screen brightness and environment to reduce reflection and glare and wear proper optical correction for refractive errors. The investigation additionally indicates that educational institutions ought to organize sufficient intervals between instructional sessions and communicate these guidelines to students to forestall computer vision syndrome during classes (3).

Furthermore, a recent study conducted in Bangladesh found that 68.16% of post-secondary students experienced computer vision syndrome (CVS) symptoms due to the increased usage of digital devices for online education and entertainment during the COVID-19 pandemic. The symptoms that are most frequently observed are headache, feeling of worsening eyesight, and eye pain. The study also identified various factors associated with the development of CVS, including the use of mobile or tablet devices, participating in continuous online education for a period exceeding 12 hours per day, with no breaks or insufficient breaks, while having a history of eye problems or headaches in one's family or personal background (5). Additionally, another study found that none of the samples investigated had sufficient sleep quality (25).

Studies conducted among students and general communities have reported similar findings, as indicated (5, 21). Healthcare staff also experience a high prevalence of CVS symptoms, with rates exceeding 46% despite variations in exposure hours and job categories. Furthermore, over 50% of participants reported poor sleep quality (27).

Most studies investigating the relationship between CVS and sleep quality have concentrated on student populations, possibly due to their higher exposure to electronic devices. Despite variations in reported values for CVS and sleep quality across different methods and populations studied, the incidence of CVS and poor sleep quality remains consistently high regardless of society or occupational group (28). Furthermore, with the growing use of electronic devices, the incidence of these issues will probably continue to increase.

Numerous studies have investigated the potential impact of monitor usage on CVS symptoms (21, 25, 27-32). Research has shown a positive correlation between the frequency and duration of monitor usage and the occurrence of visual discomfort and related symptoms. Liu et al. employed statistical models to investigate this relationship and found that reducing monitor usage by one hour is associated with a 16% decrease in the likelihood of experiencing vision-related disorders (29).

Extended use of monitors in non-ergonomic positions has been associated with various vision problems, including dryness and eye discomfort. For example, when users excessively elevate the height of their monitors, it alters their line of sight and increases corneal exposure to air. Consequently, there is an increase in eye fluid evaporation, reduced tear film quality, and the development of dry eyes (29, 33, 34). Furthermore, prolonged monitor use has been found to decrease the normal blinking rate, with some studies reporting rates as low as 3.6 blinks per minute compared to the average rate of 18.4 blinks per minute (26, 30, 34-36). This reduction in blinking rate may be attributed to increased screen focus and decreased secretion capacity of the eye glands, resulting in an uneven distribution of tears on the eye's surface (37, 38).

Several studies have investigated the relationship between screen time and sleep quality (25, 30, 31). As instance, a review article highlighted that 90% of the studies examined found a connection between screen time and reduced sleep duration (39). Moreover, individuals who dedicate an extended period to engaging with electronic displays are more prone to encountering disturbances in their sleep patterns (9).

The impact of screen light on the circadian rhythm of individuals is well-documented. The retina comprises light-sensitive neurons called ipRGCs that estimate the brightness levels in the environment (40). The retinohypothalamic tract, which originates from these ipRGCs, regulates melatonin secretion (41). In other words, the melanopsin photoreceptors in the eye transmit information to the suprachiasmatic nucleus (SCN) of the hypothalamus, which contains neurons that regulate the circadian rhythm by controlling melatonin secretion from the pineal gland in response to

environmental conditions, particularly light and darkness (42). Melatonin, in turn, governs the physiological regulation of sleep.

Due to their durability and stability, LEDs have become the most prevalent display and light-emitting source in electronic devices such as computers and mobile phones (2). Although the emitted light is commonly perceived as white, the peak of the LED emission is in the blue light spectrum, which is similar to the peak sensitivity of melatonin suppression (43). Consequently, this light is detected by photoreceptors and transmitted via the retinohypothalamic tract to the SCN. Exposure to this light, which has a wavelength close to that of melatonin suppression, obstructs melatonin secretion, resulting in disruptions to people's circadian rhythm (2).

In addition to disturbing the circadian rhythm, using electronic devices can lead to increased engagement in virtual environments, resulting in delayed sleep and continued mental activity even after bed (44). Furthermore, prolonged exposure to digital screens can cause muscle pain, further interfering with the sleep process (45).

In a study conducted by Kim et al., the Korean adult community reported a significant relationship between the duration of sleep and the incidence of visual symptoms (7). In another study, sleep duration was lower in people with CVS (3). Gupta et al. found a similar relationship between dry eyes and sleep quality among female students (47). Notably, more than 65% of individuals reporting dry eyes also had severe sleep problems, in line with a study that linked insufficient sleep to higher rates of severe dry eyes (48). Liu et al. developed a model to examine the relationship between sleep duration and eye discomfort syndrome and found that for each hour increase in sleep duration, the likelihood of eye discomfort syndrome decreased by 23% (33). Another model demonstrated a notable correlation between reduced duration of sleep and heightened severity of eye discomfort.

Studies have shown that sleep disorders and inadequate sleep can lead to increased tear osmolarity, decreased tear film break-up time, and reduced tear secretion, all of which can cause or intensify ocular surface diseases (49). Sleep disorders also impact the function of the lacrimal glands, resulting in reduced tear secretion. Sleep disorders also affect the function of the lacrimal glands, leading to reduced tear secretion. Furthermore, discomfort and visual weakness may persist when the eye muscles do not have sufficient recovery time during sleep (3).

As previously discussed, there is a correlation between digital device usage and both CVS and sleep quality. Moreover, all studies indicate a direct relationship between CVS and poor sleep quality, which may be attributed to excessive screen time and the released blue light emission. The influence of other factors may further intensify this correlation. For example, Akiki et al. found that the presence of stress can significantly amplify the impact of CVS on migraine and insomnia. Specifically, the relationship between CVS and migraine can increase by 53%, while the relationship between CVS and insomnia can rise to 80% (50). Furthermore, inappropriate ergonomic practices can also increase the likelihood of CVS symptoms and poor sleep quality in individuals (51).

The studies conducted among students and general communities have reported similar findings, indicating that the incidence of CVS and poor sleep quality remains consistently high regardless of society or occupational group. Furthermore, with the growing use of electronic devices, the incidence of these issues will probably continue to increase. Therefore, it is crucial to develop educational and corrective programs to mitigate CVS symptoms and promote healthy sleep habits.

Since ocular issues and sleep disruptions can have detrimental impacts on various physical and cognitive domains, resulting in work fatigue and decreased performance during tasks, neglecting to address the conditions of utilizing digital displays and devices may threaten an individual's professional or academic trajectory. Hence, raising awareness among individuals about the potential risks of excessive screen time and the importance of taking breaks, adjusting screen brightness, and using proper optical correction for their refractive errors is essential. Additionally, it is necessary to implement ergonomic practices and develop policies that promote healthy digital device usage to reduce the incidence of CVS and poor sleep quality. Therefore, it is crucial to develop educational and corrective programs to mitigate CVS symptoms and promote healthy sleep habits.

Based on the search results, the limitations of the research on the relationship between computer vision syndrome (CVS) and sleep quality in users of digital displays are not explicitly stated. However, some studies have identified factors that increase the risk of CVS, such as decreased sleep quality, high computer use duration, and a non-ergonomic position. Other studies have found a significant association between poor sleep quality and CVS. Additionally, some studies have reported a high prevalence of both CVS and poor sleep quality among undergraduate students. Therefore, it is important to consider these factors when interpreting the study's results on the relationship between CVS and sleep quality in users of digital displays.

Conclusion

In conclusion, the literature review has shown that the extensive use of electronic devices has led to an increase in Computer Vision Syndrome (CVS) and a decline in sleep quality, which are related to the amount

of digital device usage and the prolonged use of devices emitting blue light. The studies have consistently reported a direct relationship between CVS and poor sleep quality, which may be attributed to excessive screen time and the released blue light emission. The influence of other factors such as stress and inappropriate ergonomic practices may further intensify this correlation.

Conflict of interest: None declared.

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