Association Between Visual Acuity, Ocular Pathology and Refractive Error with Computer Vision Syndrome: Cross Sectional University Study in Kenya

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Abstract

Background: Numerous factors have been shown to reduce symptomatic and non-symptomatic forms for computer vision syndrome. However, little is known on the impact among computer users diagnosed with severe symptoms of computer vision syndrome. The study assessed whether reduced visual acuity, ocular pathology and refractive error are associated with computer vision syndrome.

Methods: A cross sectional university based study in Kenya. Seven hundred and eighty three participants were included in the study. Visual acuity was determined using snellens chart and converted to logMAR chart. Ocular pathology was determined through comprehensive examination using a slit lamp. Computer vision syndrome was determined using a validated questionnaire. Finally Retinoscopy was conducted to determine the type of refractive error.

Results: Participants with refractive error above ± 0.50 dioptres had a greater odds, multivariate adjusted ratio 0.73 (95% CI 0.63-0.90) for developing computer vision syndrome. Similar to visual acuity with multivariate adjusted odds ratio of 0.31 (95% CI 0.24-0.47) and ocular pathologies being significantly associated with computer vision syndrome (p=.04). Ocular condition like sub conjunctival hemorrhage was not significantly associated with computer vision syndrome (P=.12).

Conclusion: Reduced visual acuity, presence of ocular pathology and refractive error were associated with greater likelihood of computer vision syndrome. Particularly among those who had never had optical correction. Eye care providers are well placed to come up with proper diagnosis of CVS.

Background

Computer vision syndrome (CVS) is a multi-factorial disease of the eye that result in symptoms of stress and eye discomfort among computer users.[1] It is the leading 21st century technology related condition that manifest in the eye. It accounts for (0.2%) of visual impairment globally.[2] Computer vision syndrome presents as ocular and non ocular depending on the duration of computer use, lightning, glare, high screen brightness and improper workstation setup[3]. While CVS severity is dependent on modifiable risk factors, behavioral factors remain the key preventive measure. Current management for CVS entails modification of behaviour, however this limits the prognosis[4]. The behaviour aspect is associated with burden since the computer user must self observe them during computer use. Therefore additional research should be conducted to assess the effectiveness of self management. Since no curative treatment for CVS exists, it is critical to address ocular related pathologies and refractive error wherever possible.

Computer vision syndrome has been shown to arise from complicated pathophysiological mechanisms such as ocular surface, accommodative and extra ocular mechanisms[5]. Environmental factors have been shown to play an important role in the pathophysiological mechanisms for CVS. Whereas, symptoms are largely temporary, some individuals may experience continued reduced visual abilities even after stopping

computer work and if nothing is done to address the cause of the problem, the symptoms will continue to recur and perhaps worsen with future computer use[6]. Computer vision syndrome related study reported a significant reduction in the symptoms from non ocular related pathology to ocular pathology (OR 0.84; 99% CI 0.49–0.94)[7]. Ocular related mechanisms remained the key confounding factor. The follow up study included visual acuity with removal of ocular related symptoms due to association with eye irritation, asthenopia and dry eye. The results showed that ignoring ocular surface mechanism influenced development of CVS. However, association of visual acuity and CVS is desired.

The Indian eye study, a population based study reported that ocular pathologies presents with similar symptoms like those for CVS[8]. There was an association between prolonged period of computer use and CVS. Therefore, the clinicians should make a proper differentiation between CVS presentation and other ocular pathologies. A meta-analysis showed an association between CVS and dry eye. Being insidious and subtle, CVS is often less perceptible among computer users. Uncorrected refractive error being an issue of public health concern has not been evaluated to ascertain its association with CVS[9]. However, currently there is no epidemiological data showing association between CVS and ocular pathologies with uncorrected refractive error[10]. The data is significant due to the confusion among eye care providers on clinical presentation of CVS and other ocular conditions. This study aims to document the association between reduced visual acuity, ocular pathology and uncorrected refractive error among university students with CVS. The data will be useful in adding literature on CVS and enhance accuracy in diagnosis by eye care providers.

Methods

Study population

The study participants 18-39 years were recruited from Maseno University in Kenya from February 2019 to March 2019. Participants who had low vision were referred for low vision care. Of the 790 participants, 650 were diagnosed with CVS. Three participants were diagnosed with low vision while 137 were negative for CVS. An Informed consent was obtained from all participants and the study sought approval from Institutional Review Board of Maseno University and permission to conduct the study from National Commission for Science and Technology. The study adhered to the tenets of the Declaration of Helsinki. Each subject was given a bottle of soda and a bread to compensate for their time and accepting to participate. Participants diagnosed with refractive error were advised that they need to seek optometrist or ophthalmologist for a pair of spectacle. Other abnormalities detected were also referred for a more detailed care.

Study procedures

A comprehensive ocular examination was conducted among the participants. The procedures conducted include slit lamp examination, Retinoscopy, direct ophthalmoscopy and taking the visual acuity. Visual acuity was tested using a snellens chart and converted to logMAR for analysis, with a pin hole done after

the presenting visual acuity taken. Slit lamp examination evaluated the anterior segment for any sign of ocular pathology. The presence of pterygium, corneal scar and lid pathologies were recorded. Retinoscopy was conducted for participants who had visual acuity score of 6/9 to 6/18 on both eye after an improvement on pin hole. After the comprehensive assessment, face to face interviews were conducted with trained interviewers where comprehensive information on computer use was recorded. Aspects on computer use such as duration of computer use were recorded. The team consisted of ten optometrists and five research assistants. The research assistants were trained thoroughly on research related issues and specifically on this topic. They were taught on what the study was all about and procedures in conducting interviews.

Assessment of clinical features of computer vision syndrome

The presence of CVS was recorded among participants who reported symptoms of eyestrain, eye fatigue, burning sensations, irritation, redness, blurred vision, and dry eyes. Reporting these symptoms with an ocular pathology such as conjunctivitis, keratitis and sub-conjunctival hemorrhage required a more comprehensive assessment before making a conclusion that it is CVS. The visual acuity of participants was assessed using snellens chart and graded as >6/12 normal, <6/12 to >6/24 mild and > 6/60 moderate. Participant's information was recorded for the second phase of interview on computer vision syndrome. For the best corrected visual acuity, participants who required a prescription of $\geq \pm 0.50$ dioptric (D) were considered positive for refractive error. Participants who had normal visual acuity and no ocular pathology were grouped together during interviews on CVS.

Assessment of computer vision syndrome

Computer vision syndrome was assessed using a validated 8-item self assessment CVS questionnaire[10]. The participants were given a date on when the study shall be completed. On the final day they were interviewed by one of the research assistants with a structured questionnaire. The questionnaire assessed the participants on the symptoms they experienced while using computers. The questionnaires were administered seven days after the examination among the group which had visual acuity of 6/9 to 6/18 and ocular pathologies. The questionnaire had been pretested during a pilot to asses for Cronbach's' reliability of 0.956 and validity (assessed by performing a Pearson correlation coefficient and obtained0.000<0.05, n=78). The response rate was 99.1% and this was enhanced by maintaining a constant contact between the participants and the researcher at all time during the study period. The confounding factors included the self-reported characteristics by participants: age, gender, seating position, duration of computer use and history of ocular conditions such as low vision.

Statistical analysis

Statistical analysis was carried out using Statistical Package for Social Sciences software (SPSS; version 17.0). Logistic regression analysis was carried out to determine the associations between CVS with visual acuity, ocular pathology and refractive error and is recorded as adjusted odds ratios (ORs) with 95% confidence intervals (CIs). Chi-square test was used to compare the visual acuity scores, ocular pathology

and refractive error with CVS. All P values less than 0.05 were considered statistically significant. Linear regression analysis was performed to assess associations between CVS and presence and absence of refractive error.

Results

Various study characteristics of the participants involved in the cross-sectional study are presented in Table 1. The median age of participants was 26 years with (57.2%) being men; (49.3%) of participants had a substantive refractive error and (3.9%). Less than half (22.3%) of the participants practiced the appropriate preventive measures for CVS.

Table 1
Study characteristics with CVS

Demographic	Participants with CVS (n = 783)	P value
Age (year)	543 (69.4)	
Male gender	447 (57.2)	0.01
Duration of computer use	582 (74.3)	0.045
Seating position	503 (64.3)	0.032
Visual acuity		
> 6/12	9 (1.2)	
< 6/12 to > 6/24	542 (69.3)	0.02
6/60	175 (22.4)	
Correction		
Wearing glasses	8 (1.0)	
Not wearing glasses	775 (99.0)	0.03
Ocular pathology		
Allergic Conjunctivitis	613 (78.3)	0.02
Keratitis	10 (1.3)	0.04
Sub conjunctival hemorrhage	31 (3.9)	0.12
Refractive error		
< 0.50 D	188 (24.0)	
≥ 0.50 D	548 (70.0)	0.04
Note: Data are presented as n (%)		
Abbreviations: CVS, computer vision syndrome		

About three quarter of the participants (69.4%) who had no refractive error experienced less CVS symptoms. Allergic conjunctivitis was present among (78.3%) who experienced CVS with keratitis being (23.1%) and sub-conjunctival hemorrhage (1.3%). Participants who had a refractive error of < ± 0.5 compared to ≥ ± 0.50 had (54.0%) reduced odds for presence of CVS, with multi variate odds ratio of 0.65 (95% CI 0.45–0.83) (Table 2). A threshold analysis reported that participants having refractive error above verses below ± 0.50 had reduced odds of CVS, after age gender adjustment odds ratio of 1.25 (95% CI

0.56–1.74). Increasing refractive error score was significantly associated with CVS. The visual acuity < 6/18 was significantly associated with computer vision syndrome.

Table 2
Association between parameters and CVS

Variables	Age- gender adjusted OR(95% CI)	Multivariate adjusted OR (95% CI)
Refractive error		
< 0.50 D	0.65 (95% CI 0.45–0.83)	0.70 (95% CI 0.65–0.89)
≥ 0.50 D	1.25 (95% CI 0.56–1.74)	1.73 (95% CI 0.63–1.90)
Visual acuity		
> 6/12	0.05 (95% CI 0.01–0.08)	0.15 (95% CI 0.10–0.19)
< 6/12 to > 6/24	0.10 (95% CI 0.02–0.12)	0.24 (95% CI 0.16–0.32)
> 6/60	0.21 (95% CI 0.12–0.35)	0.31 (95% CI 0.24–0.47)
Abbreviations: CI, confidence interval and OR, odds ratio		

In addition, participants who had visual acuity less than 6/18 had a higher risk of developing CVS (P = .02). Increasing ocular pathologies such as allergic conjunctivitis and keratitis are significantly associated with CVS. Sub-conjunctival hemorrhage was not significantly associated with CVS. Participants who had refractive error reported more symptoms of CVS unlike those who never had refractive error (70% and 24% respectively). We also looked at the association between wearing a correction and CVS and out of the n = 13 who had a full correction, (1.0%) reported symptoms of CVS. However, (99.0%) reported that without the prescription they experienced CVS symptoms. For participants who had reduced visual acuity, (69.3%) experienced the symptoms of CVS odds ratio of 0.21 (95% CI 0.12-0.0.35). On a threshold analysis participants who had retinal issues verses those without had greater odds of CVS: odds ratio of 0.40 (95% CI 0.29–0.75).

Discussion

This study ascertains that uncorrected refractive error, reduced visual acuity and presence of ocular pathologies are associated with great odds for presence of CVS. A threshold affects for visual acuity with a score of 6/9 conferred minimal influences on CVS. We ascertained that the study outcomes remains intact even with exclusion of low vision participants. However, certain ocular condition such as sub-conjunctival hemorrhage was not significantly associated with CVS. The rest of the observed parameters such as reduced visual acuity, uncorrected refractive error and some ocular pathology were significantly associated with CVS. It is necessary that ophthalmologists and optometrists correct refractive error and properly manage the ocular diseases as this will reduce the symptoms of CVS. Previous studies have

investigated more on CVS with a bias to modifiable risk factor[11]. One of the referenced studies conducted in India, grouped participants into 3 groups, where one group was exposed to computer for 7 hours, the second group exposed for 1 hour and the final group was a placebo[12]. The placebo group had significantly lower odds of developing CVS compared to the exposed group for 7 hours a day (OR 0.46; 99% CI 0.36–0.87)[12]. The study did not assess other aspects like ocular pathologies hence limiting generalization on CVS and other ocular conditions. However, there are no epidemiological data from a population based study that link CVS with reduced visual acuity, uncorrected refractive error and ocular pathology. In sum, uncorrected refractive error, reduced visual acuity and ocular pathologies are associated with CVS, however, current evidence has not concluded exhaustively on how these relationships occur. Therefore clinicians are well placed to factor all possible causes of CVS and clearly differentiate them from other ocular pathologies.

Shrivastava et al reported that managing ocular conditions such allergic conjunctivitis reduces the severity of CVS while other conditions do not[13]. The finding is in line with our results where ocular pathologies are associated with CVS. However, the lack of association between CVS and some ocular pathology could be attributed to uncovered factors that had impact on visual acuity. Other conditions which might have not been detected during examination could have impacted on the association. Obtaining the visual acuity through longitudinal data could be more accurate; however it was not within the scope of the study. By contrast, a study conducted in India by Azuhairi et al, reported that participants with reduced visual acuity due to refractive error who had correction experienced significantly less CVS symptoms than those without correction[14]. In 2012, the authors also reported that reduced visual acuity may expose a computer user to CVS[15]. In overall the studies are not providing sufficient evidence why reduced visual acuity influences CVS. Our study found that reduced visual acuity was associated with a higher chance of developing CVS since an individual has to accommodate more hence resulting to straining. While experiencing eye irritation, dry eye and asthenopia gives a good prognosis for CVS, a study in Nepal showed that looking at the symptoms alone does not warrant CVS[16]. In comparison to a study conducted in Ethiopia among bank workers where diagnosis was based only on symptoms [17]. In sum most eye care providers still make diagnosis based on symptoms reported by computer users. This is attributed to quick diagnosis without conducting a comprehensive examination to rule out the possible. We can assert that the reason for the significant associations between CVS and visual acuity is due to adequate study power. Our findings show that computer users who wear glasses do not experience the CVS symptoms and a possibility of high work productivity.

Various treatment options for CVS exist. Our study results show that uncorrected refractive error is associated with higher odds of developing CVS. This suggests that correcting refractive error could highly reduce CVS as uncorrected refractive error is an underlying cause. As mentioned initially, the magnitude of refractive error is a great factor for CVS. A study conducted in Canada showed that there was no strong association between refractive error and CVS[18]. Similarly, another study found that there was no strong association between refractive error and CVS[19]. However, these studies did not conduct a comprehensive examination to justify their conclusions. Further research should be conducted to clarify

the confusion between the association between uncorrected refractive error and CVS. An eye study conducted in India compared computer users based on uncorrected refractive error and found that there was a significant association in experiencing symptoms of CVS[20, 21, 22, 23, 24]. From our study, sub-conjunctival hemorrhage is not associated with CVS. This might be influenced by other factors as the condition majorly arises from trauma to the eye which is rare. Therefore a more intense study should be conducted to determine the ocular conditions underlying CVS. Refractive error makes an individual to strain while focusing, hence more likely to report symptoms similar to that of CVS. Not more studies have been conducted to assess the association between visual acuity, refractive error and ocular pathology with CVS. Therefore not much comparison can be made as this may be the first study on this topic to the best of our knowledge.

The study had certain strengths. Firstly a large sample of participants with CVS was used with a more detailed data collected. The study took a longer period of time to develop a tool to obtain more accurate data on CVS and the associated factors. A comprehensive examination was conducted to rule out all confounding factors which may bias diagnosis of CVS. The study participants were recruited from 5 universities from different parts of the country hence cause and effect easily determined. Limitations of the study, include being unable to get a linear relationship on visual acuity score and the magnitude of refractive error. Additionally, participant's refractive error was not classified based on nature and an error of ≥ 0.050 D justified a refractive error. Other factors which influenced the associations might have not been prioritized.

Conclusion

In conclusion, CVS is a condition where symptoms are largely temporary, and some individuals may experience continued reduced visual abilities even after stopping computer work and if nothing is done to address the cause of the problem, the symptoms will continue to recur and perhaps worsen with future computer use. Computer vision syndrome management is purely behavioral therefore it is important to assess how effective self management is. The study findings for this study may seem significant as it is the first study to show the reduced visual acuity, refractive error and ocular pathology are strongly related to CVS. Optometrists and ophthalmologists should adopt a convincing method of diagnosing CVS and differentiate it from other ocular conditions. The findings suggest that refractive error is strongly associated with symptoms of CVS. Hence the findings suggest for more longitudinal studies. The findings from this study should inform eye care providers to critically evaluate the cause of CVS without narrowing on the symptoms alone. The eye care providers should rule out all possible causes of CVS before making a final diagnosis and management should be narrowed at the cause.

Declarations

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Author's contributions

SM initiated the research concept, developed the proposal, did the data collection and wrote the manuscript. DO and PO improved the research concept assisted with proposal development and reviewed the proposal, analyzed data and the manuscript. All authors contributed equally to the research work. The authors read and approved the manuscript

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Availability of data and materials

The dataset for the students generated and analyzed during the current study are available from the corresponding author upon reasonable request. Due to confidentiality issues as this was a study involving human beings, the corresponding author will issue the data upon substantive request.

Ethics approval

Ethical approval was obtained from the institution review board of Maseno University. Participation was voluntary, and the respondents could withdraw from the survey at any time during the study period. The responses were kept confidential, and the data were de-identified before data analysis. The study adhered to the tenets of the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

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

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