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The Relationship of Color Perception Disorder and Computer Vision Syndrome in Medical Students

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ABSTRACT

Introduction: Computers have become an important part of modern life. Students are the example of computer users in educational environment. Long-term use of computer or video display terminal causes a group of disorders called computer vision syndrome (CVS), which characterized by ocular, visual, and musculoskeletal symptoms. Impaired color perception is one of the symptoms of CVS. Blue light exposure from the VDT screen damages retinal photoreceptor cells and has bad impact for people in carrying out their daily activities. This study aims to determine the relationship between color perception disorder and CVS in medical students.

Method: This is a prospective analytic observational study with a cross sectional approach, conducted in Denpasar Bali from October 2019 until January 2020. The sample of this study is the fifth semester medical students, with total of 217 students. the relationship between CVS and color perception disorder were analyzed by bivariate and multivariate technique, controlled by age, gender and duration of computer use.

Results: This study shows 56,7% students with CVS, which 18,70% of them experienced color perception disorders. The analysis showed that individual with CVS had 2,47x higher risk of color perception disorder, compared to non-CVS students (p=0,025).

Conclusions: This study concluded there is a changing in color perception that occurs in individual with CVS. We suggest further research on subjects with wide age range and other type of occupation which exposed to phototoxic radiation.

Keywords: Computer vision syndrome, Color perception disorder, medical student.
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INTRODUCTION

Computers have become an important part of modern life today. The use of video display terminals (VDT) are widespread in offices, schools and households. A survey by The European Working Conditions (2010) showed 30% of workers were using computer all day while working and 25% of them used it for half of their working time.[1] Students are the group of computer users in educational settings, as a tool for completing tasks and recreation.[2] The use of computers or VDT for a long time causes various disorders called computer vision syndrome (CVS).[3]

Computer vision syndrome is a group of ocular, visual and musculoskeletal symptoms caused by excessive computer use. However, not all computer users experience CVS. This is influenced by the duration of computer use, distance from the eye to the computer screen, light intensity, use of anti-glare glasses, and the surrounding environment.[1] Disturbance of color perception is one of visual symptom of CVS. Exposure to blue light from the VDT screen damages the photoreceptor cells in the retina, namely S cone cells, which results in acquired color blindness. Prolonged S cone damage can be irreversible and is often not realized by CVS patients.[4]

Color blindness testing is needed in multidiscipline environment, such as industry, education, and government, due to human dependence on work or education which is closely related to color. The Farnsworth Munsell-Hue 100 (FM-100) panel is a test to detect and diagnose both congenital and acquired color vision disorders. This FM-100 test can determine the evaluation of color perception or disturbances in deutran, protan, or tritan color deficiency.[5]

Acquired color perception disorders will have a negative impact for people in carrying out daily activities. Until now, only a few research to determine the association of color perception disorders in students with CVS has been published. Based on this, this study was conducted to determine that color perception disorders, examined by the FM-100, are related to computer vision syndrome in medical faculty students.

RESEARCH DESIGN AND METHOD

Ethics Approval

The prospective analytic observational study adhered to the tenets of the Declaration of Helsinki. This study has registered in Prof. Dr. I.G.N.G. Ngoerah / Sanglah Hospital, Bali. The study protocol was approved by the Ethic

Committee of Udayana University, Prof. Dr. I.G.N.G. Ngoerah /Sanglah Hospital, Bali with ethical clearance no. 2707/UN14.2.2.VII.14/LP/2019.

Study Design

This is a prospective analytic observational study with a cross sectional approach. The research was held at the eye clinic of General Hospital and medical faculty in Denpasar, from October 2019 until January 2020. The sample was the fifth semester students of medical faculty.

The inclusion criteria of this study were computer users with or without computer vision syndrome who are active and currently studying at medical faculty and willing to become research samples by filling out the informed consent. The exclusion criteria were students suffering from partial color blindness, experiencing eye disease in the form of corneal disorders, lens abnormalities and a history of optical neuropathy, using drugs that could affect color perception, for example chloroquine, digoxin, ethambutol, hydrochloroquine, phenytoin, sildenafil, and tamoxifen in the past two months, as well as refused to be the subject of this study.

The procedure of this study is as follows: (1) Distribution of study questionnaires to the students of medical faculty; (2) Students with and without CVS (based on the results of the questionnaire) are examined by the researcher. The examination includes general ophthalmology examination and color perception examination using the FM-100 panel; (3) The FM-100 examination procedure, each student arranges 89 color discs in order of chromaticity, starting with the color of the reference disc. The results of the FM-100 examination were recorded. The results obtained were entered into the FM-100 software to be analyzed and expressed in degrees of normal, light, moderate and severe color blind.

Statistical Analysis

The general characteristics and distribution of various variables are described using descriptive statistical analysis. Categorical scale data are described in terms of frequency and percentage, while for numeric scale data are in the form of mean and standard deviation (SD). Normality test using the Kolmogorov-Smirnov. The relationship between changes in color perception and CVS was tested with a 2x2 cross table. The magnitude of the relationship between the two variables is stated by the Odd Ratio (OR) with a confidence interval (CI) of 95%. Multivariate analysis with logistic regression to determine the effect of age, gender and computer duration on color perception disorders.

RESULTS

The study sample was all fifth semester students of medical faculty. All identified samples who met the inclusion and exclusion criteria were included in the study, with a total sample of 217 participants. The characteristics of the study sample and screen time are shown in **Table 1** and **2**.

The characteristics of the color perception disorder in the study sample are shown in **Table 3**. Students who experienced color perception disorders were 31 people (14.3%), where the majority had a non-specific pattern (96.8%) and only one person had a tritan pattern (**Figure 1**). Most of the color perception disorders were mild (93.5%). The relationship between CVS and color perception disorders in this study is shown in **Table 4**. Of the total 31 people who experienced color perception disorders, 23 of them experienced CVS and eight people

Table 1. The Characteristics of Study Sample

Characteristic	Mean ± SD	Percentage n (%)	CVS (n=123)	Non-CVS (n=94)
Age	20.09 ± 0.51			
Gender				
Male		111 (51.2)	64 (52.03)	47 (50.0)
Female		106 (48.8)	59 (47.97)	47 (50.0)
Total Error Score (TES)	25.72 ± 25.85			

Table 2. The Characteristics of Computer Usage

Characteristic	Total (n=217) n (%)	CVS (56,7%) (n=123)	Non-CVS (43,3%) (n=94)
Computer usage (year)			
< 5 years	22 (10.1)	9 (7.32)	13 (13.83)
≥ 5 years	195 (89.9)	114 (92.68)	81 (86.17)
Computer usage duration in a day	90 (41.5)	36 (29.27)	54 (57.45)
< 4 hours	127 (58.5)	87 (70.73)	40 (42.55)
≥ 4 hours			
Resting time while using computer	197 (90.8)	109 (88.62)	88 (93.62)
Yes	20 (9.2)	14 (11.38)	6 (6.38)
No			
Type of computer screen			
Cylinder	3 (1.4)	3 (2.44)	0 (0.0)
Flat screen	214 (98.6)	120 (97.56)	94 (100.0)
Eye to monitor distant			
< 50 cm	128 (59.0)	78 (63.41)	50 (53.19)
≥ 50 cm	89 (41.0)	45 (36.59)	44 (46.81)
Monitor contrast			
Light background, dark font	165 (76.0)	88 (71,54)	77 (81.91)
Dark background, light font	52 (24.0)	35 (28.46)	17 (18.09)

without CVS, with the OR of CVS for color perception disorders of 2.473, statistically significant (p = 0.025).

The influence of gender, age, duration of computer use with CVS were analyzed using logistic regression (**Table 5**). After adjusting the factors for age, gender, and duration of computer use, significant results were obtained for the effect of CVS on the incidence of color perception disorder (p = 0.029).

Table 3. The Characteristic of Color Perception Disorder

Characteristic	n (%)
Color perception disorder	
Yes	31 (14.3)
No	186 (85.7)
Type of disorder	
Diffuse (Non-specific)	30 (96.8)
Tritan	1 (3.2)
Grade of disorder	
Mild	29 (93.5)
Moderate	2 (6.5)

Table 4. The Relationship between CVS and Color Perception Disorder

	Colour perception disorder n (%)	Normal colour perception n (%)	OR	95% CI	p*
CVS					
Yes	23 (18.70)	100 (81.30)	2.473	1.052-5.811	0.029
No	8 (8.51)	86 (91.49)			

*Significant if $p < 0.05$

Table 5. The Association of CVS and color perception disorder after controlled by Age, Gender, and Accumulation of daily computer usage

Variable	B	SE	AOR	95% CI	p*
Gender	0.160	0.394	1.174	0.542-2.543	0.684
Age	0.136	0.410	1.145	0.513-2.557	0.741
Accumulation of daily computer usage	-0.279	0.418	0.756	0.334-1.715	0.504
CVS	0.996	0.457	2.707	1.106-6.624	0.029*

*Significant if p < 0.05; AOR = *Adjusted Odd Ratio*

DISCUSSIONS

This study was conducted on the fifth semester students of medical faculty, with a total sample of 217 students. The study subjects who experienced CVS were 123 people (56.7%). Several other epidemiological studies have shown similar results to this study. A study in India of information technology (IT) students showed a CVS prevalence of 55.46%.[6] Ranasinghe et al. reported a CVS incidence of 67.4% of a total of 2.500 office workers in Sri Lanka.[7] A similar study was conducted on university students in Malaysia, and found 90% of students who use computers for more than two hours per day experience disorders related to CVS.[2] In a study of medical students in Chennai, it was found that 78.6% of students experienced CVS.[8] This shows that disorders caused by VDT are already a global problem faced by various levels of society. The prevalence of CVS in this study tended to be less than in other studies, because the CVS assessment in this study was only based on ocular and visual symptoms.

The results of this study indicate that the students who experiencing CSV have used a computer for more than five years (92.68%). A study conducted in Chennai of office workers in the IT sector, showed an increase in the prevalence of CVS related to the length of time working with computers (in a range of years), but not statistically significant.[9] Another study by Jack, stated that the main cause of CVS is a chronic exposure to VDT without awareness of the subject.[10] Many experts argue that the visual disturbances experienced by CVS sufferers are felt to be heavier from year to year due to cumulative symptoms.[11]

The majority of the samples who experienced CVS in this study used computers for more than four hours daily (70.73%). The length of working hours using computers has been widely studied as a risk factor for CVS. Similar results were obtained in another study conducted on engineering students, found that 76% of the sample began to complain of CVS symptoms when using a computer for more than two hours daily.[6] The minimum duration of computer use daily which is considered save has not been determined. However, some studies suggest that computer use more than eight hours in a day is a significant risk factor for CVS associated with dry eye disease.[11] Resting between computer usage for at least 15 minutes has been found to have a comfortable effect on the eyes and reduce the symptoms of CVS.[12,13] In this study, 88.62% of samples with CVS rested during computer usage.

The distance between the eyes and the computer screen affects the emergence of CVS complaints. The closer the eye is to the monitor, the more the effort of eye accommodation, causing symptoms of CVS. A study conducted by Jaschinski et al stated that the distance between the eye and the monitor that is safe to prevent CVS is between 60-100 cm.[14,15] In this study, most of the samples who experienced CVS used a computer within a distance of less than 50 cm (63.41%).

The total of sample who experienced color perception disorder in this study was 31 people, of which 30 people had a non-specific (diffuse) pattern, while one person had a tritan color disorder. Samples with CVS who experienced color perception disorders were 23 people (18.70%). In this study, individual with CVS symptoms had a 2.47x higher risk of experiencing color perception disorders than individual without CVS. The results of the multivariate analysis also showed that CVS was a factor affecting the occurrence of color perception disorders. After controlling the factors for age,

gender, and duration of computer use, significant results were obtained for the effect of CVS on the incidence of color perception disorder. Many experts state that the blue light (short wavelength) emitted from a computer screen has a phototoxic effect on the photoreceptor cells in the retina.[16] Cumulative exposure to light with a wavelength of 380-500 nm activates all-trans-retinal in the outer segments of the photoreceptor cell and induces the production of reactive oxygen species (ROS), such as hydrogen peroxide and other free radicals, resulting in cell death.[17,18] This is proven in a study by Heydarian et al, where 15% of welding workers were exposed to phototoxic light in the long duration experiencing color perception disorder.[19]

CONCLUSION

The occurrence of acquired color perception disorders is multifactorial, caused by a chronic process. Color perception disorders in computer vision syndrome are often mild so that the individual does not realize it. In this study, the examination of color perception using FM-100 was carried out on students after doing physical activities so that there was a fatigue factor.

CONFLICT OF INTEREST

There is no conflict of interest regarding this article

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