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Original Article

ANALYSIS OF THE MULTIFOCAL ELECTRORETINOGRAM OUTCOMES OF COMPUTER VISION SYNDROME: A PROSPECTIVE OBSERVATIONAL CROSS-SECTIONAL CASE-CONTROL STUDY

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Abstract

Purpose: *To analysis of the multifocal electroretinogram outcomes of computer vision syndrome (CVS).* ***Methods:*** *In this observational cross-sectional case-control study, 59 students were grouped into CVS-diagnosed (n=36 eyes) and control (n=23 eyes). All completed the CVS-Q questionnaire and had mfERG testing to evaluate foveal function.* ***Results:*** *We documented statistically significant reduction in foveal responses in CVS versus control groups in mean mfERG Rings 1 and 2 with Quadrants 2 (P=<0.002, 0.02 and 0.01, respectively.* ***Conclusion:*** *This study documented the screen-induced foveal dysfunction that associates CVS using mfERG examination which revealed significant reduction in foveal responses in CVS group versus control group.* ***Clinical Trials Registration:*** *ClinicalTrials.gov (ID: NCT06106347).*

Keywords: *Digital eye strain, Computer vision syndrome, Screen-induced foveal dysfunction, Multifocal electroretinogram.*

1. Introduction

Over the past two decades, widespread computer adoption has significantly streamlined office tasks by merging diverse activities (typing, filing, reading) into prolonged desk-based work, markedly improving productivity and efficiency [1]. By 2000, approximately 75% of all occupations involved routine computer use, [1] coinciding with rapid growth in home computer ownership—from about 15% in 1990 to nearly 50% by 2000, driven largely by affordable internet access [2]. This extensive digital engagement has led to Computer Vision Syndrome (CVS), characterized by visual (blurred vision, diplopia), ocular (dryness, redness, irritation), and extraocular symptoms (headaches, neck, shoulder, and back pain) [3-5]. Notably, even three hours per day of digital device usage significantly increases CVS risks, affecting adults and especially children who regularly use devices for schoolwork and entertainment [4,6]. In developed countries, digital device usage has risen sharply across all age groups, placing millions at risk [7,8]. whereas developing countries experience a greater burden due to limited access to protective equipment and insuf-

ficient breaks during prolonged device use [9]. CVS represents a major occupational and public health challenge, significantly impacting productivity, increasing errors, and lowering job satisfaction [10]. Primary contributing factors include poor ergonomics, incorrect viewing angles and distances, prolonged continuous usage, and suboptimal environmental conditions such as improper lighting, screen glare, excessive brightness, low contrast, and slow screen refresh rates [11]. Multifocal electroretinography (mfERG)—a recent advancement utilizing a stimulus array of 64 or 103 contrast-reversing hexagons—enables simultaneous assessment of retinal function across the central 30–40° visual field, providing valuable spatial information to diagnose visual pathway disorders when standard clinical examinations yield uncertain findings [12]. Our study rational was analysis of the multifocal electroretinogram outcomes of CVS.

2. Patients and Methods

This prospective observational cross-sectional case-control study adhered to the Declaration of Helsinki and was conducted at the Ophthalmology Department, Faculty of Medicine, Sohag University, Egypt. A total of 59 students participated, completing the CVS-Q questionnaire and categorized into two groups: Group A (CVS-positive, n=36) and Group B (CVS-negative controls, n=23). Inclusion criteria were age ≥18 years and corrected distance visual acuity (CDVA) ≤0.00 logMAR. Exclusion criteria included hyperopia (>3 D), myopia (>6 D), astigmatism (>±3 D), current ocular pathology or inflammation, glaucoma, amblyopia, retinal diseases, contact lens use, previous ocular/refractive surgery, history of ocular medication use, and near vision abnormalities. Participants from both groups underwent mfERG assessment with the SuperColor Ganzfeld Q450SC device, following the standard ISCEV protocol. Testing employed a 61-hexagon stimulus on dilated pupils, with outcomes referenced against system-generated age-matched norms. Statistical analysis was conducted using STATA 17.0 (Stata Corp LP, TX). Data normality was determined with the Shapiro–Wilk test. Quantitative results were summarized using mean ± SD or median and range, and group comparisons employed Student's t-test or Mann–Whitney test, as appropriate. Qualitative outcomes were reported as number (%), analyzed by Chi-square or Fisher's exact test. Spearman correlation assessed associations between variables. Statistical significance was established at p <0.05.

3. Results

This study enrolled 59 students (mean age: 23.13 ± 0.58 years), comprising 34 males and 25 females, divided into a CVS group (n=36) and a control group (n=23). Regarding the control group, the mean of R1 and R2 were 75.98±48.86 and 27.35± 11.82 respectively (Mean ± SD). Furthermore, the mean of R3, R4 and R5 were 7.61±6.05, 4.57±3.30 and 3.05±1.98 respectively (Mean ± SD). Moreover, the mean of Q1 and Q2 were 4.68±4.37 and 12.84±2.84 respectively (Mean ± SD). In addition, the mean of Q3 and Q4 were 4.86±3.38 and 5.78±4.85 respectively (Mean ± SD). On the other hand, regarding the CVS group, the mean of R1 and R2 were 31.81±30.04 and 17.73± 16.50 respectively (Mean ± SD). In addition, the mean of R3, R4 and R5 were 7.76±6.07, 4.07±3.80 and 3.45±2.55 respectively (Mean ± SD). Furthermore, the mean of Q1 and Q2 were 4.00±2.81 and 5.03±3.13 respectively (Mean ± SD). Moreover, the mean of Q3 and Q4 were 3.73±2.07 and 4.26± 2.33 respectively (Mean ± SD). As shown in tab. (1) & figs. (1 & 2), mfERG results

showed overall reduced responses in both groups. However, R1, R2, and Q2 showed significantly better function in the control group (P = 0.0002, 0.02, and 0.01). Screen-induced foveal dysfunction (SFD) was present in 84.21% of CVS cases compared to 18.18% of controls ($P < 0.0001$). Figures (3 & 4) illustrate preserved foveal responses in two control eyes, whereas fig. (5 & 6) demonstrate diminished foveal activity in two CVS-affected eyes.

Table 1: the mfERG outcomes in the control versus the CVS groups

Parameters	Control Group *n=23 (Mean ± SD) Median (Range)*	CVS Group *n=36 (Mean ± SD) Median (Range)*	Mean difference *95% confidence interval*	P Value
mfERG findings:				
I- Amplitudes P1(nV/deg2):				
Ring 1 (normal 54.9—151)	75.98±48.86 68.29 (10.96:154.9)	31.81±30.04 20.69 (0:110.4)	44.17 (23.82:64.52)	**0.0002**
Ring 2 (Normal 30.1—69.6)	27.35±11.82 24.06 (13.07:59.54)	17.73±16.50 13.20 (0:66.2)	9..62 (3.05:18.68)	**0.02**
Ring 3 (Normal 19.2—39.7)	7.61±6.05 7.12 (0:28.81)	7.76±6.07 6.69(0.19:22.13)	-0.15 (-3.29:2.98)	**0.97**
Ring 4	4.57±3.30	4.07±3.80	0.50	
(Normal 10.0—28.5)	3.76 (0.20:14.54)	2.91 (0:20.32)	(-1.45:2.45)	**0.26**
Ring 5 (Normal 8.2—25.4)	3.05±1.98 3.39 (0:9.32)	3.45±2.55 2.57(0.25:10.17)	-0.41 (-1.67:0.86)	**0.87**
II- Amplitudes P1 (nV/deg2):				
Quadrant 1	4.68±4.37 3.72 (0:17.89)	4.00±2.81 3.38 (0:14.8)	0.67 (-1.18:2.53)	**0.88**
Quadrant 2	12.84±2.84 8.28 (4.02:16.81)	5.03±3.13 4.57 (0:15.98)	7.81 (3.82:10.44)	**0.01**
Quadrant 3	4.86±3.38 3.61 (0.47:11.71)	3.73±2.07 4.02 (0:8.24)	1.13 (-0.27:2.53)	**0.44**
Quadrant 4	5.78±4.85 4.49 (1.00:23.21)	4.26±2.33 3.92 (0.37:10.6)	1.51 (-0.34:3.37)	**0.29**
III- Foveal functions:				
Normal foveal response (eye) **Reduced foveal response (eye)**	**18 eyes (81.82%)** **4 eyes (18.18%)**	**6 eyes (15.79%)** **32 eyes (84.21%)**		**<0.0001**

mfERG: *multifocal electroretinography;* ***Amplitudes P1:*** *amplitude density of the first foveal peak;* ***deg:*** *degree;* ***nV:*** *nanovolts;* ***SD:*** *standard deviation; CVS, computer vision syndrome*

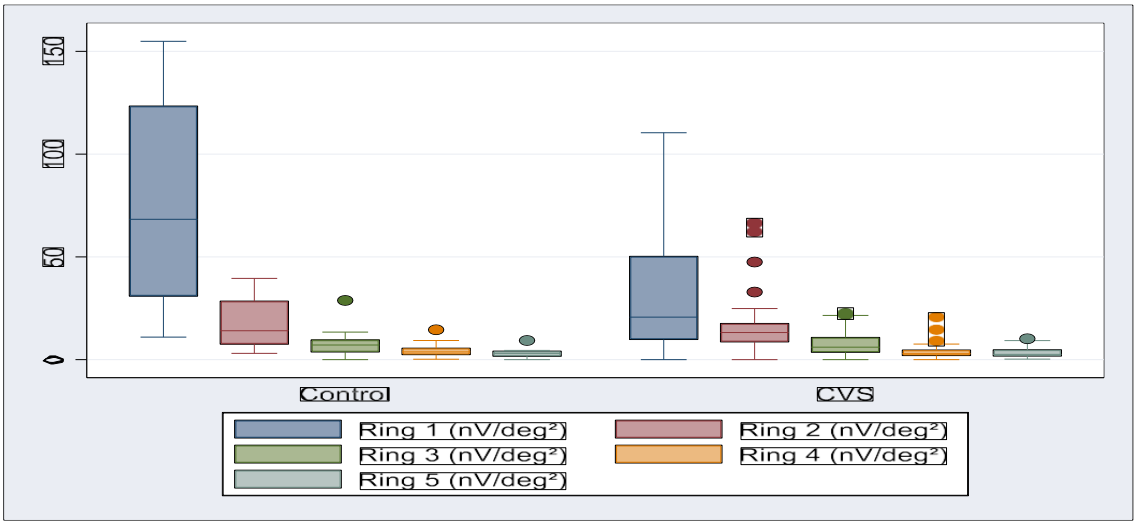

Figure 1: the mfERG Rings outcomes in the control versus the CVS groups

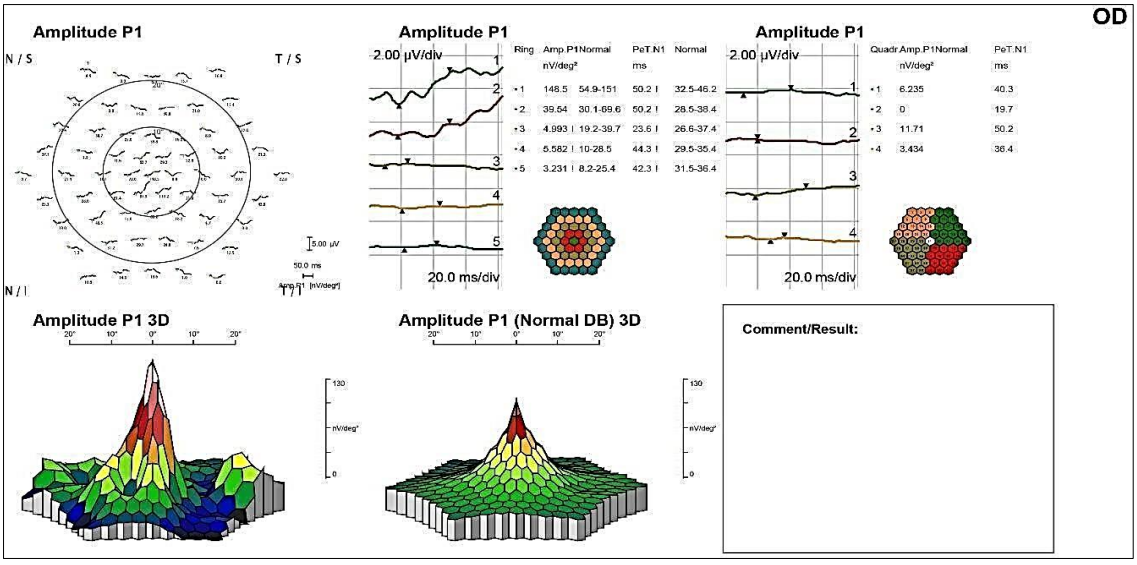

Figure 2: the mfERG Quadrant outcomes in the control versus the CVS groups

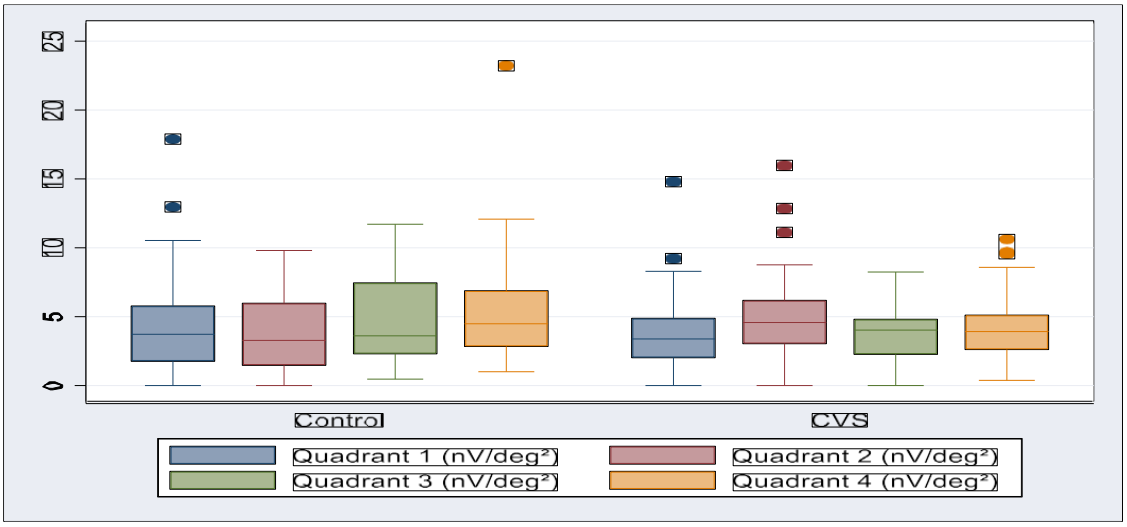

Figure 3: the mfERG preserved foveal responses in right eye of a student in the control group

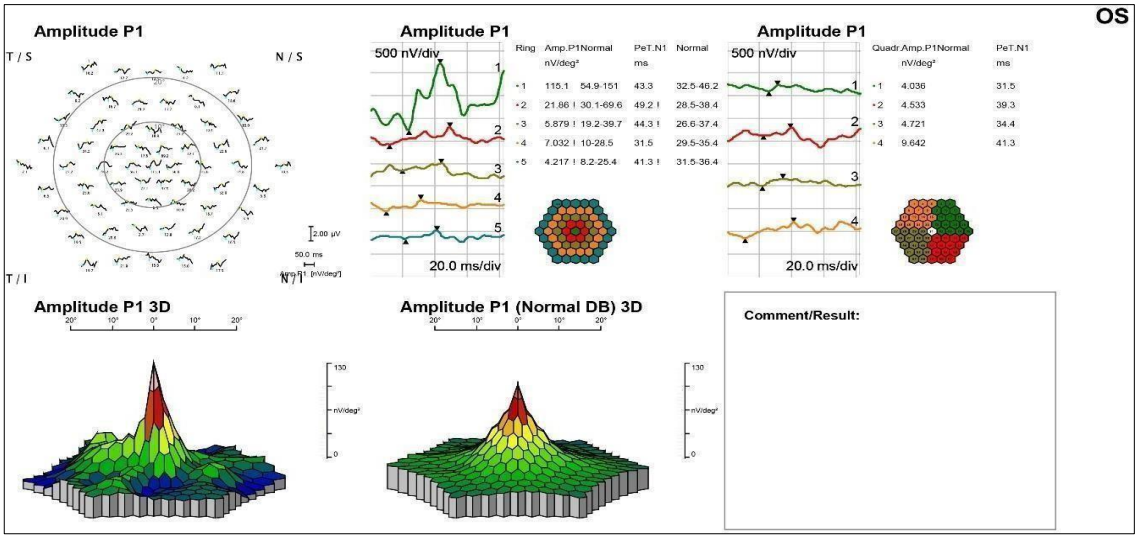

Figure 4: the mfERG preserved foveal responses in left eye of another student in the control group

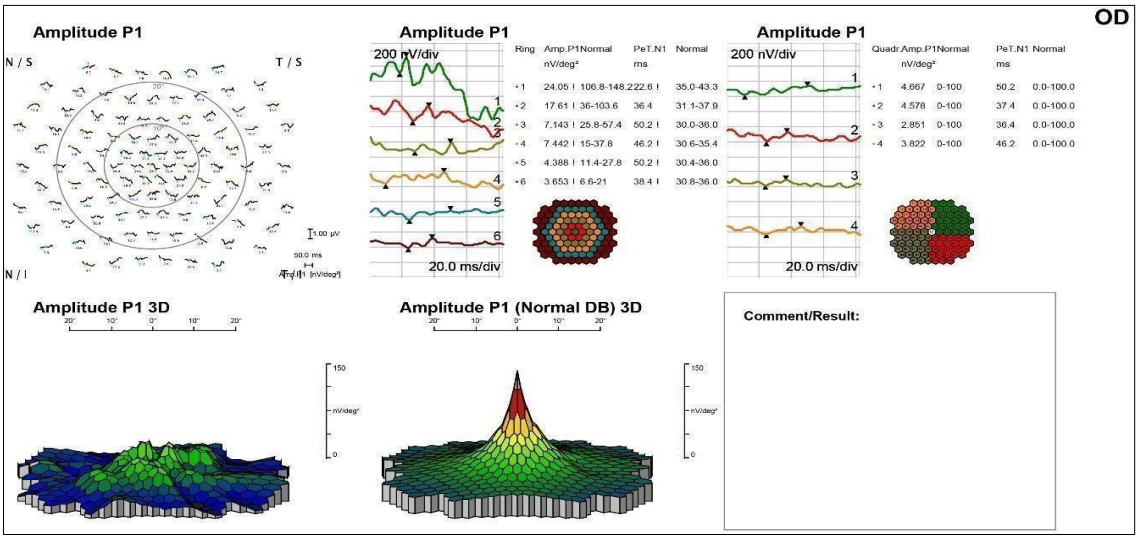

Figure 5: the mfERG reduced foveal responses in right eye of a student in the CVS group

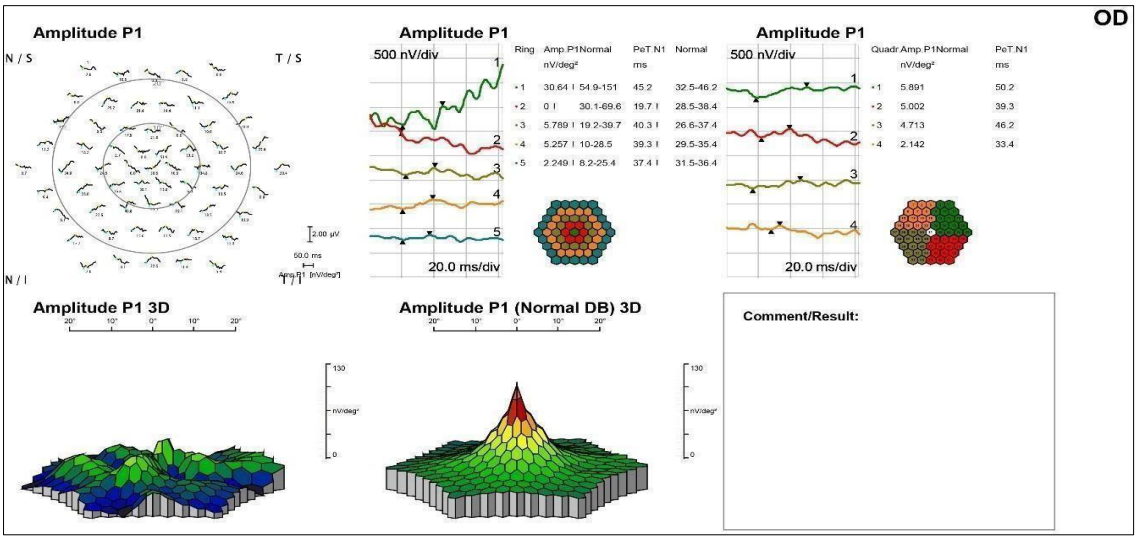

Figure 6: the mfERG reduced foveal responses in right eye of another student in the CVS group

4. Discussion

This study included 59 students in Sohag University. It included 36 male and 23 females with a mean age of 23.13±0.58 years (mean±SD). CVS diagnosis was confirmed by subjective questionnaire; the CVS-Q. This questionnaire revealed 63.3% CVS prevalence rate among the study students. The study participants were classified into a control group (no CVS) and a CVS group. In Egypt, Iqbal et al [13] reported 58.78% CVS prevalence rate among 6853 medical students at 15 Egyptian universities using the CVS-F4 online questionnaire. Moreover, they also reported 64.7% CVS prevalence rate among 461 medical students using the CVS-Smart questionnaire. Furthermore, they revealed a higher CVS prevalence rate among females (65.87%) than males (48.06%). On the other hand, our study recorded 63.3% overall prevalence rate of CVS based on two questionnaires CVS-Smart and CVS-Q questionnaires with a higher prevalence rate among males (81.25%) than females (28.57%). This could be attributed to our small sample size (60 medical students) compared to the larger sample size in Iqbal et al. (6853 medical students). Meanwhile,

we instructed our study CVS and DED positive-cases to lower their screen-time and follow the modified Iqbal's instructions by Iqbal et al [13]. In other interesting studies by Iqbal et al [14,15] they investigated the visual and mfERG foveal response outcomes of 4 weeks reduction of average daily screen-hours to one hour daily. Their cohort comparative study investigated 49 medical students (49 eyes). Their study participants responded to the CVS-Form 3 (CVS-F3) questionnaire and were subjected to complete ophthalmic and mfERG examination. Their CVS diagnosis was based on Iqbal's 4 major diagnostic criteria including comprehensive ophthalmic examination. On the other hand, we used both CVS-Smart and CVS-Q questionnaires for CVS diagnosis alone beyond Iqbal's 4 major criteria. In addition, we also use the OSDI questionnaire for DED diagnosis which in not the case in their study. However, in line with our results; both above mentioned studies documented generalized reduction in the mfERG foveal responses meanly R1 and R4 the mfERG Rings denoting the existence of the SFD. In line with Iqbal et al [14,15], our study found a significant link between screen time and mfERG R1 amplitudes. While Iqbal et al. described a positive correlation between reduced screen time and improved R1 P1 amplitudes, we observed a negative correlation between screen time and foveal response. Both findings convey the same conclusion: lower screen exposure enhances foveal function. However, we observed a major difference between the previous two studies by Iqbal et al [14, 15] and this current study. They reported a negative correlation between the differences (post- minus pre- screen-time reduction) in the average daily screen-hours and the differences in the UDVA, four weeks following screen-time reduction i.e. the greater the differences in the average daily screen-hours thus the lower the average daily screen-hours, the greater the negativity in the logMAR thus the greater the UDVA improvements. Their findings were against our outcomes as we observed that there was no correlation between average daily screen-hours and UDVA in this current study. This major difference could be explained on the basis that they actually recruited a large number of medical students for their clinical trial, yet unfortunately; only a small number of students (49 medical students) who were greatly suffering from the CVS symptoms and sequelae including the temporally deterioration in visual acuities while the larger number of students refused to reduce their screen-time as they were not complaining thus reduction of screen-time was not justified to them. Therefore, only high-risk subjects contributed in their study thus UDVA revealed great improvements following screen-time reduction. Hence, the previously mentioned negative correlation was easily documented in their study. On the other hand, our study revealed 0.00 logMAR CDVA in all study participants with statically insignificant vision-related function subscale of OSDI score thus indicating good visual acuities of all study subjects with no correlations between daily screen-hours and either UDVA or CDVA [14,15]. Recently, Iqbal et al [16] has defined the term screen-induced foveal dysfunction (SFD) as the multifocal electroretinogram reduced foveal responses below standard normal ranges that are mostly temporary, reversible and usually associated with reduced visual acuities and performances in computer vision syndrome positive-cases. This was the first published obvious and established definition of SFD. In 2021, Iqbal et al [16] was the first scientific team that published the first article announcing the existence of SFD in positive CVS-cases using mfERG examinations and finally concluded that CVS positive cases might be associated with reduced foveal responses that accompanied the reduced visual performances. However, they acknowledged that the underlying pathophysiological mechanisms of SFD are unknown but it might be related

to macular cone/bipolar cell dysfunction due to exposure to light emitting diodes (LEDs) that emits a large amount of blue light that might or might not be responsible for this phenomenon [16,17]. Iqbal's criteria are well established criteria of CVS diagnosis [18-23] that included screen-induced foveal dysfunction (SFD) as visual and retinal sequelae of CVS. According to Iqbal et al., screen-induced foveal dysfunction (SFD) is characterized by subnormal mfERG foveal responses that are usually transient and reversible, often accompanied by diminished visual acuity and functional performance in CVS-positive individuals [18-23].

5. Conclusion

This study concluded that exposure to digital devices has an inverse impact on foveal responses. That means the more daily screen-hour exposure, the more reduction on foveal responses. So, we recommend lowering the daily screen-hours to protect against the CVS

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