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Evaluation of Visual Function with Different Illumination for Diabetic Retinopathy Patients Post Ocular Management

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ABSTRACT

Background: India, the country with the most diabetics in the world with over 62 million diabetics. As increase in diabetes which is directly proportional to increase number of diabetic retinopathies in future

Aim: To evaluate the visual performance of diabetic retinopathy patients after ocular treatment with various LED lights

Methodology: This experimental investigation comprised 35 diabetic retinopathy patients treated with laser treatment or Anti-VEGF medication. On the basis of MN Read guidelines, participants with best-corrected visual acuity (BCVA) between 1.3 Log MAR and -0.5 Log MAR were included in the research. The comprehensive optometric assessment comprised a detailed medical history and best-corrected visual acuity (BCVA) for distance and near. The patient's reading performance was next evaluated with MN Read acuity in three light circumstances, i.e., normal room illumination, an overhead projection of white LED and yellow LED, and constant 400 lux intensity

Results: The mean age of the participants was 58.6 ± 6.44 years. Data were analysed using one-way ANOVA for comparison of reading and functional performance under normal room illumination, white LED and yellow LED in diabetic retinopathy patients' post-treatment. The scores derived from this analysis showed that there is no significant difference between reading performance, functional performance, and different illumination (p=0.05)

Conclusion: Present study conclude that lighting had no influence on reading performance (Critical print size, reading speed, and reading acuity) and functional performance (Contrast sensitivity and colour vision) in diabetic retinopathy patients after therapy. Nevertheless, present study data indicate that white lighting increased reading speed and yellow illumination enhanced colour vision in diabetic retinopathy patients after therapy.

1. Introduction

The wavelength of light beams and the amount of energy they carry have an inverse relationship. Light rays with comparably long wavelengths carry less energy, whereas those with short wavelengths have more energy. Rays in the red end of the visible spectrum have longer wavelengths and, thus, less energy and vice versa (Dunbar & Melton, 2013). The colder the white light is, the greater the percentage of blue light will be: compact fluorescents (CFLs) contain around 25 % of blue light, whilst light-emitting diodes (LEDs) contain about 35 percent of blue light. Blue light is also part of the LED display on most displays, and this is a growing source of exposure for many individuals. A narrow spectrum of blue light (between 415nm and 455nm) is particularly damaging to the retina. In terms of direct damage to the front of the eye, long wavelengths such as UV light may be more relevant in terms of cataract development. In contrast, shorter wavelengths like blue light likely to cause greater damage to the retina. For persons who suffer macular degeneration, it is deemed vital to give protection against blue light (Dunbar & Melton, 2013). There are both visual and non-visual processes behind these advantages of light: Visual mechanisms are delivered in a way that is consciously perceived, and their benefits include an increase in productivity and a reduction in the risk of falls for people with low vision; non-visual mechanisms are not directly perceived, but have a significant impact on circadian rhythms and affect both mood and sleep (Brunnström et al., 2004; Butler, 2017). High-quality lighting is characterized

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by an acceptable quantity of light and the right direction of the light, as well as perfect luminance conditions, excellent contrast, low glare, and a suitable selection of light fittings. Inadequate lighting makes it difficult for visually impaired persons to do everyday tasks, especially because they need high-quality light to improve their vision (Brunnström et al., 2004). Lighting is one method of task adaptation; thus, one of the first things to do for those with limited vision is to provide them with adequate work lighting.

The function will also be impacted by the overall distribution of light since the aging eye fails to adjust from bright to dark and vice versa. Therefore, it is essential that the light from a work lamp be evenly distributed so that shadows do not develop; this facilitates the general functionality of an individual with age-related vision loss. Every activity has its own lighting requirements; for instance, threading a needle takes less than preparing toast. Yet, we are aware that the illumination levels in the homes of older persons with limited vision routinely fall below the minimum levels required for any given job. According to studies, age, DR severity, and visual acuity, all have a significant impact on how well DR people live their lives. The results indicated that although therapy might enhance the social and emotional well-being of DR patients, it was unable to raise their scores for other visual abilities. Patients with diabetic retinopathy who have low vision frequently struggle with tasks like recognizing faces, reading bus numbers from a distance, reading small, low-contrast print, writing straight lines, being sensitive to light, moving outside after dusk, shopping, cooking, and finding food, seeing the time on a watch, and telling apart similar-sized coins and banknotes (Yang et al., 2018; Turco et al., 1994; Shrestha & Kaiti, 2014) Thus, the present study emphasizes on impact of illumination on visual functions.

2. Material & Methodology

The Lotus Eye Hospital, College of Optometry, and Eye Solutions - The Complete Eye Hospital all participated in the present research. The research was authorised by the chair of the local ethics committee at Lotus Eye Hospital and College of Optometry after receiving the written permission of all patients. Participants in this experimental research were chosen from the archival records of the Low Vision and Retina departments at Lotus Eye Hospital and Eye Solutions - The Complete Eye Hospital. Before being included in the study, each participant was given comprehensive written material along with a description of the study's purpose and had to provide written informed consent. The research comprised 35 diabetic retinopathy patients who had laser therapy along with anti-VEGF treatment. Patients with diabetic retinopathy who had had laser treatment at least three months before and anti-VEGF medication at least one month prior were included since studies have indicated that stabilisation of vision occurs by that time. Participants between the ages of 40 and 81 were included in the research since reading speed is thought to be similar in this age range (Wong et al., 2018; Chen et al., 2019). The research recruited individuals with English and Marathi as their first languages and adequate reading skills. On the basis of MN, participants with best-corrected visual acuity (BCVA) ranging from 1.3 Log MAR to -0.5 Log MAR were included. The research included readability requirements (Mansfield & Legge, 2006).

All patients who had already had vitrectomy were disqualified. Other eye conditions such as age-related macular degeneration, glaucoma, vitreous hemorrhage, and posterior subcapsular cataract that might affect reading skills were also disregarded. Patients with hypertension were also disqualified from the trial because it may cause retinopathy. The research also removed 62 patients who were unable to read the MN read chart. On binocular inspection, all measurements and analyses were conducted. Based on calculations and information from the literature study that was chosen by quantitative random selection, a sample size of 31 was chosen (Chow et al., 2017). The preparatory investigation and experimental stages of the two phases that made up the present research. The amount of light was measured using a digital photometer (Thermocare Digital Lux Light Photo Meter). The following three lighting options were selected: White LED lighting is 5-watts, 6500 Kelvin colour temperature; yellow LED illumination is 8-watts, 2700 Kelvin temperature; and normal room illumination is 10-watts, LED tube light. A digital photometer was used to measure the intensity at 1 metre, which was maintained constant at 400 lux. This constant intensity was determined by prior research and different photometric standards (Ram & Bhardwaj, 2017; Ram & Bhardwaj, 2018). The MNREAD reading chart was utilised to evaluate reading proficiency. Colour vision was evaluated using HRR Pseudo-isochromatic Plates, 4th Edition, while contrast perception was measured using a Pelli-Robson Contrast Sensitivity Chart and distance perception using a CSV-1000E chart. Participants were comfortably situated in a dark, quiet room.

2.1. Preliminary Phase Procedure

The patient attended the centre for two days throughout the study's two stages, with the first day serving as the preparatory phase and the second as the experimental phase, during which reading comprehension and functional performance were evaluated. Every patient's thorough medical history was obtained on the first day. In order to treat diabetic retinopathy, a history of laser therapy, including the number

of sessions, the number of shots, and the strength of the laser shots, as well as an anti-VEGF history, including the number of injections administered and the most recent anti-VEGF dosage history, was obtained. All patients had their eyes refracted, and the best-corrected visual acuity (BCVA) for each eye was assessed using the Log MAR chart for distance and close in addition to their medical histories. Any patient who needed low-vision equipment got one and had time to get used to it. Patients were contacted the next day or a few days after the first test to gauge their reading and functioning abilities.

2.2. Experimental Phase Procedure

All three lighting scenarios were used for the experimental methods (Normal room, White LED, and Yellow LED illumination). Near BCVAs were worn by the patients. Following an evaluation of the participant's reading comprehension under these lighting conditions, contrast sensitivity was measured (at a distance and up close), and the HRR chart was used to test the participant's colour vision. Because it aids in the detection of both Red-Green and Blue-Yellow colour deficiencies, HRR Pseudo isochromatic plates, 4th Edition, were used to test colour vision. The patient is shown how the test works using the first four plates. The most challenging Protan, Deutan, and Tritan (red, green, yellow, and blue) targets are shown on the following six plates (screening series). The subject passes the test and is deemed to have "normal colour vision" if they are successful with these plates. The next 14 plates make up the diagnostic series and provide an assessment of the defect's kind and degree (mild, medium, or strong) (Protan, Deutan, Tritan). Studies have shown that most patients with diabetic retinopathy experience a blue-yellow colour vision defect (Nilsson, 1986; Cole et al., 2006). Each light source had a fifteen-minute adaptation period under it. Utilizing the MNREAD acuity charts, reading performance was evaluated (Figure 7). Standardized sentences are presented in a variety of letter sizes on the MNREAD reading chart. On the chart's reversed side, the letters become smaller as the size drops logarithmically. It consists of a string of phrases totalling 60 characters, written in three lines with equal margins on the left and right (with spaces between each word and at the conclusion of each line). This figure shows the size of sentences ranging from a high of 1.3 log MAR to -0.5 log MAR, each decreasing by 0.1 log unit (at a viewing distance of 40 cm) (Mansfield & Legge, 2006). At a distance of 40 cm, binoculars were used for the test. As the phrases were revealed one at a time from big to tiny type, the patients read aloud as quickly and precisely as they could. A portable stopwatch was used to record the number of seconds it took to read each phrase. The number of mistakes made for each phrase was recorded on a score sheet and translated using the manner outlined in the test instructions to reading speed in words per minute. The following formula was used to determine the reading performance: The reading acuity (RA) in log MAR was calculated using the formula: RA=1.4 – (sentences read × 0.1) + (errors × 0.01). Reading speed was calculated in words per minute using the formula: Reading speed =60× (10 – errors)/ (time in seconds)

Binocular distance contrast sensitivity measurements were carried out using a contrast chart from the Bynocs programme. The Pelli-Robson chart, or log contrast, is the basis for the contrast sensitivity chart in the Bynocs programme. The patient's distance from the screen was 2 metres. The chart employs groupings of letters, six per line, with varying contrast from high to low. The patient was instructed to list the names of all the letters on the chart, beginning with the bold letters in the top left corner and moving down the whole line. When the patient failed to properly identify two or more letters in a triplet, the test was terminated. A near Pelli-Robson chart was used to measure the binocular near contrast sensitivity. Pelli-Robson contrast chart was positioned 40 cm away. With two triplets each line, the letter sequences are arranged into groups of three (triplets). Every letter in a triplet has the same contrast. Even inside a single line, the contrast drops from one triplet to the next. The patient was instructed to list the names of all the letters on the chart, beginning with the bold letters in the top left corner and moving down the whole line. When the patient failed to properly identify two or more letters in a triplet, the test was terminated. Critical print size (CPS) was recorded as the smallest size sentence which can be read at or faster than 90% of the average of three fastest speeds recorded.

3. Results

All the experimental data was stored using Microsoft Excel software. SPSS statistical software version 25 was used for the statistical analyses of normal distributions using Shapiro-Wilk's tests. One-way analyses of variance (ANOVA) were used to explore the differences between illumination sources with reading performance and functional performance. Chi-square was performed to find an association between duration of diabetes and reading speed and near contrast for each illumination. Similarly, a Chi-square test was performed to find an association between no. of sittings/no. of Anti-VEGF with reading speed and near contrast for each illumination. A total number of 113 patients were invited for the study, out of which 36 patients participated. Among 36 patients, one of the patients was excluded as he was 38-year-old which was below inclusion criteria. Finally, this study

included 35 patients (22 male and 13 female) where 23 underwent laser therapy while 12 had Anti-VEGF therapy. All participants received written informed consent to take part in the research before inclusion. The demographic data and visual data for laser therapy and Anti-VEGF therapy [Table.1].

Table-1: Demographic and visual data of participants.

	Laser therapy (Mean ± SD)	**Anti-VEGF therapy (Mean ± SD)**
Age (years)	58.13±7.07	59.18±5.14
Duration of Diabetes (in years)	5.47±2.29	7.28±1.80
Duration of therapy	2±1 (years)	5.33±2.90 (months)
No of sittings/ Injection	2.26±1.32	1.75±0.96
Distance BCVA (LogMAR)	0.28±0.31	0.15±0.13
Near BCVA (M)	1.15±0.56	1.06±0.53

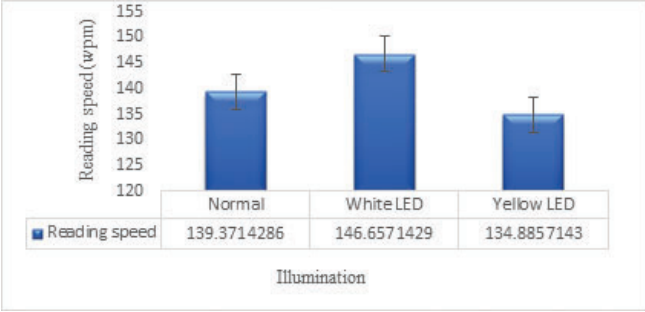

Figure 1: Graph showing reading speed under different illumination.

The relationship between reading speed and illumination was not statistically significant i.e., p>0.05 (Table 3). Reading speed was higher in White LED as compared to normal room illumination and yellow illumination as shown in Figure 1 (Table 2). Also, it was found that reading speed decreased with yellow illumination as seen in Figure 1.

Table 2: Table showing mean values of reading performance under different illumination.

Illumination	Critical Print Size (LogMAR)	Reading Speed (wpm)	Reading Acuity (M)
Room	0.21±0.1	139.37±35.46	1.07±0.5
White LED	0.20±0.1	146.66±25.11	1.06±0.5
Yellow LED	0.21±0.1	134.89±31.99	1.06±0.5

The relationship between critical print size, reading acuity and illumination was also found to be not statistically significant i.e., p>0.05 (Table 3). In the case of critical print size and reading acuity, it reduced with extra illumination as compared to normal room illumination as shown in Figure 3 and Figure 4 (Table 2).

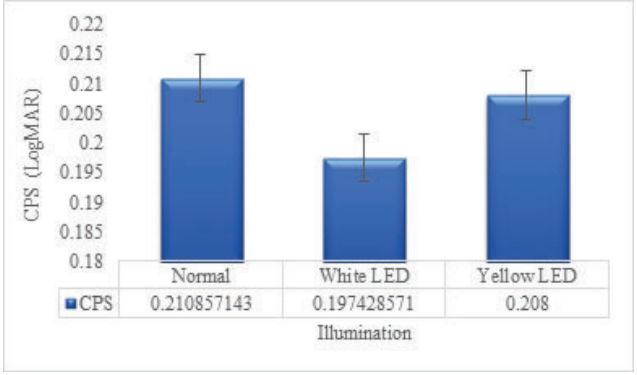

Figure 2: Graph showing critical print size under different illumination.

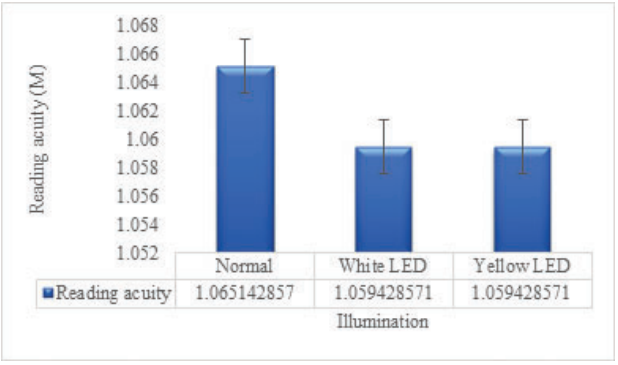

Figure 3: Showing reading acuity under different illumination.

In the case of Contrast sensitivity, there was no difference in different illumination but there was a slight decrease in contrast sensitivity for both distance and near under white illumination as compared to normal illumination and yellow illumination as seen in **Error! Reference source not found.**. But according to ANOVA, there was no statistically significant difference between illumination and contrast sensitivity for both distance and near i.e., p>0.05 (Table 5).

Table 3: Results of reading performance under different illumination using one-way analyses of variance.

Dependent Variable	Illumination (I)	Illumination (J)	Mean Difference (I-J)	Std. Error		Sig.
Critical print size	Normal	White	.00714		.02341	1.000
		Yellow	.00000		.02341	1.000
	White	Normal	-.00714		.02341	1.000
		Yellow	-.00714		.02341	1.000
	Yellow	Normal	.00000		.02341	1.000
		White	.00714		.02341	1.000
Reading speed	Normal	White	-7.886		8.112	1.000
		Yellow	4.486		8.112	1.000
	White	Normal	7.886		8.112	1.000
		Yellow	12.371		8.112	.391
	Yellow	Normal	-4.486		8.112	1.000
		White	-12.371		8.112	.391
Reading acuity	Normal	White	.00000		.11680	1.000
		Yellow	.00000		.11680	1.000
	White	Normal	.00000		.11680	1.000
		White	.00000		.11680	1.000
	Yellow	Normal	.00000		.11680	1.000
		White	.00000		.11680	1.000

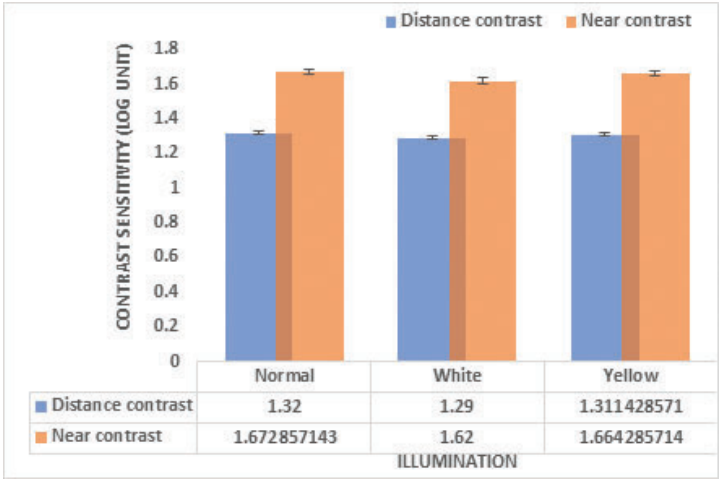

Figure 4: Graph showing contrast sensitivity under different illumination.

Table 4: Table shows mean values of Contrast sensitivity (Distance and near) and color vision.

Illumination	Contrast sensitivity (Distance)	Contrast sensitivity (Near)	Color vision
Room	1.32±0.27	1.67±0.28	0.63±1.03
White LED	1.29±0.28	1.62±0.29	0.63±1.03
Yellow LED	1.31±0.28	1.66±0.27	0.54±0.98

3.1. Difference Between Colour Vision and Illumination

For Colour vision analysis, color vision recordings were replaced with numerical value instead of color defects such as normal color vision as 0, mild B-Y defect as 1, med B-Y as 2, and strong B-T defect while R-G defect as 4. According to the statistical analysis, there was no difference seen in color vision under all illumination i.e., p>0.05, (Table 5) though there was improvement seen in 2 patients where the patient improved to normal from mild B-Y defect.

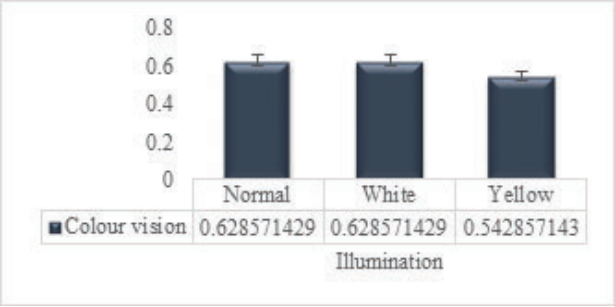

Figure 5: Graph showing color vision under different illumination.

Association between Duration of Diabetes with reading speed and near contrast sensitivity

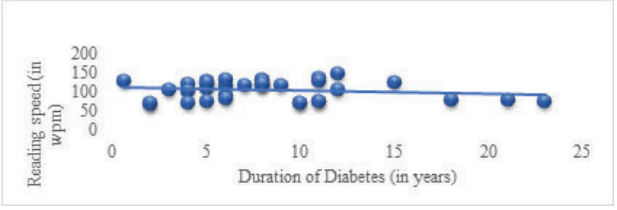

Figure 6: Scatter plot showing reading speed for the duration of Diabetes.

To rule out the association between duration of diabetes with reading speed and contrast sensitivity in each illumination chi-square was performed. It was found that there was no significant association between the duration of diabetes and reading speed under each illumination (p>0.05). Though as per our observation we found that there as the duration of diabetes increases there is a slight reduction in reading speed.

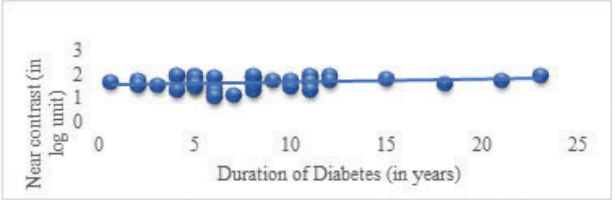

Figure 7: Scatter plot showing near contrast for the duration of Diabetes.

Similarly, in the case of near contrast, we found there was no association between the duration of diabetes and near contrast for each illumination (p>0.05).

Association between no. of sittings of laser and reading speed and near contrast:

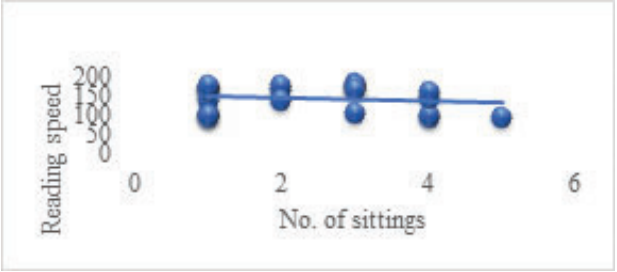

Figure 8: Scatter plot showing reading speed for laser therapy patients.

In our study, 23 patients underwent laser therapy where we also recorded their no. of sittings of laser which was of average 2.26±1.32 (Figure 8). According to Chi-square analysis, we found that there was an association between no. of sittings with reading speed for normal room illumination (p<0.05), while there was no association between reading speed and number of sittings for other two illuminations i.e White and Yellow illumination. In case of near contrast, there was no association with no. of sittings of laser for each illumination (p>0.05) (Figure 9).

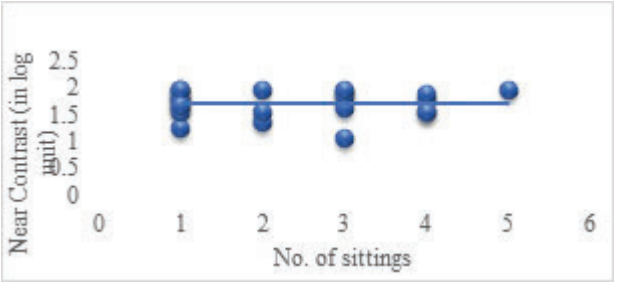

Figure 9: Scatter plot showing near contrast for laser therapy patients.

Association between no. of Anti-VEGF and reading speed and near contrast:

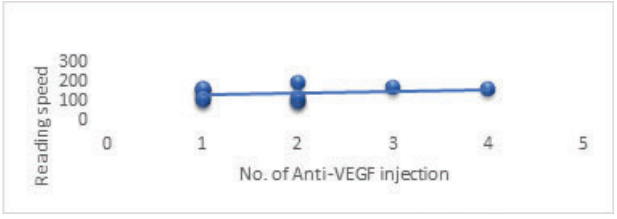

Figure 10: Scatter plot for reading speed in Anti-VEGF patients.

Out of 35 patients, 12 patients had Anti-VEGF therapy for the management of Diabetic retinopathy. While looking association between no. of anti-VEGF and reading speed it was found that there was no significant association between them ($p>0.05$) for each illumination (Figure 10). Similarly, in the case of near contrast, didn't found any significant association between no. of Anti-VEGF injections and near contrast ($p>0.05$) for each illumination (Figure 11).

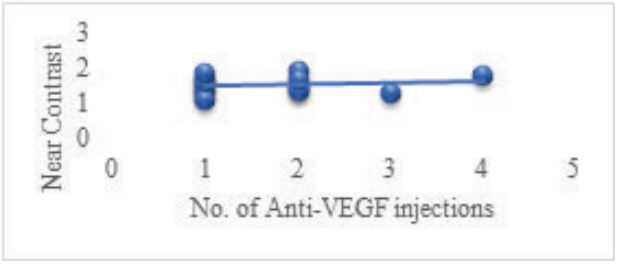

Figure 11: Scatter plot showing near contrast in Anti-VEGF patients.

4. Discussion

Current research investigated the functional and visual performance, including contrast sensitivity and colour vision, of diabetic retinopathy patients after ocular care (Critical print size, reading seed, and reading acuity). There was no statistically significant difference between reading performance and lighting in the current investigation. It was unable to locate any research demonstrating an improvement in reading ability in diabetic retinopathy patients or diabetic retinopathy patients after ocular care. Previous research has shown that lighting significantly affects CPS and reading speed in ARMD patients (Eperjesi et al., 2007). In the present investigation, it was discovered that lighting did not result in an improvement in CPS; rather, it showed that yellow illumination resulted in a drop in CPS. While there was no statistically significant difference between yellow and white lighting, Present study results did show that reading speed was quicker with the former. There was no statistically significant change in reading acuity, however there was a decline in acuity with more light (both white and yellow). Additionally, there were no statistically significant relationships between lighting and functional performance. An ancient study that tested colour vision between regular room lighting and booth illumination and discovered that colour vision improved in the booth illumination, which was white illumination, claims that there is a change in hue discrimination in diabetes with changing illumination (Ram & Bhardwaj, 2017; Smedowski et al., 2015). With the use of yellow light, one patient in the present research was able to improve their colour vision from a moderate B-Y defect to mild B-Y defect, while the other patient went from a moderate B-Y defect to mild B-Y defect.

Patients receiving post-ocular laser therapy or anti-VEGF medications for diabetic retinopathy report a reduction of contrast sensitivity (Wang & Lo, 2018). Several studies have shown that poor vision individuals, particularly those with macular degeneration, have an improvement in contrast sensitivity with an increase in light intensity. Most of the time, the light intensity has a beneficial impact on contrast sensitivity, but sometimes, not even the highest light intensity improves the contrast (Smedowski et al., 2015). The crucial differences were shown to be greater for character sizes bigger or lower than 1 degree in earlier investigations. The critical contrast, for 12-degree characters, for instance, would be approximately 0.17, and for 0.25-degree characters, around 0.33. Additionally, persons with poor vision often need extremely big character sizes—typically 6 degrees or more than what would be expected if better contrast were required for quick reading in a low-vision situation (Rubin et al., 1989). Normative values for distance contrast sensitivity for Age groups 40-49, 50-59, and 60-75 are 1.73 ± 0.13, 1.93 ± 0.06, and 1.85 ± 0.15 respectively. For near contrast, normal values for the same age group are 1.95 ± 0.07, 1.94 ± 0.08, and 1.90 ± 0.11 respectively. Present study found no variation in contrast sensitivity between far and proximity under various lighting conditions in the present investigation. In most investigations, light intensity was shown to improve, but in the present study, it maintained a 400-lux level. Current study may conclude that there is no influence of the colour temperature of light on contrast sensitivity since it utilised two distinct illuminations with varied colour temperatures. There are no studies that demonstrate that colour temperature has any impact on contrast sensitivity.

Most research show that when diabetes is present for a longer period of time, patient's functional ability declines (Khan et al., 2017). However, the reduced sample size in the present research may have contributed to present finding that there was no correlation between the length of diabetes and contrast sensitivity. When it comes to laser treatment, Functional visual performance is shown to decline as the number of laser sessions rises (Wang & Lo, 2018). However, we discovered that there was no statistically significant correlation between the number of laser sessions and the near contrast in the present investigation. This could be caused by variations in shot force or shot volume each sitting. No research has compared the number of sittings with reading comprehension. The present research looked for a relationship between the number of sittings and reading speed, and under standard room lighting, it does discover one. But no correlation was seen for other illuminations. Present study found no correlation between reading speed and the number of Anti-VEGF patients. The same might be explained by the fact that anti-VEGF treatment has a lot less

of an impact on visual performance than laser therapy does (Stefanini et al., 2014). Additionally, in the present research, the majority of Anti-VEGF patients had a maximum of 3 injections, which may be much too few to have any impact on visual function.

5. Conclusion

The study's findings suggest that lighting has no impact on individuals with diabetic retinopathy's post-treatment reading performance (Critical print size, reading speed, and reading acuity) or functional performance (Contrast sensitivity and colour vision). However, present study results imply that yellow lighting enhanced colour vision and white illumination accelerated reading speed in diabetic retinopathy patients after therapy.

6. Acknowledgement

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7. Competing Interests

The authors declare that no competing interests exist

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