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Research Article

Comparison of Blue Block Lenses and Anti-Reflection Coated Lenses on Reading Speed and Visual Fatigue

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Abstract

Purpose: To compare the effect of blue block lenses and anti-reflection coated (ARC) on reading speed in visual display unit (VDU) and printed chart and on visual fatigue questionnaire.

Methods: A double-masked, controlled crossover study was carried out on 146 healthy subjects (92 males and 54 females) aged 18 to 30 years who used digital devices for a minimum two hours daily. The duration of the study was August 2019 to February 2020. Baseline visual fatigue questionnaire response and reading speed with hard coated lenses on digital MNRead and printed MNRead was recorded. Subjects were then divided into two groups by randomization. A well-fitted spectacle with blue block lenses was given to the first group and ARC lenses to the second group. After a week, the response to the visual fatigue questionnaire and reading speed was noted. Hard coat lenses were given for a week to wean off the previous lenses' influence if any. Then the intervention was crossed over and the response of the visual fatigue questionnaire and reading speed data were collected again after a week. All the collected data were compiled and statistically analyzed using ANOVA-Fisher's test.

Results: Blue block lenses had a significant increase in reading speed in terms of words per minute (WPM) compared to baseline and ARC lenses in both VDU and printed chart. Blue block lenses showed a WPM of 137 (± 23.3) in VDU and 145 (± 23.3) with the printed chart ($p < 0.001$). ARC lens showed WPM of 128 (± 17.7) in VDU and 135 (± 17.7) in the printed chart ($p < 0.001$). While the baseline recording with hard coat lenses was WPM of 123 (± 27.2) in VDU and 134 (± 20) with the printed chart. While a significant decrease in symptoms of digital eye strain was noted with the usage of blue block lenses, especially in terms of dryness, eye fatigue in the visual fatigue questionnaire ($p < 0.001$).

Conclusions: Blue block lenses were more effective with respect to reading speed and reducing digital eye strain as compared to ARC lenses. In our study, the blue block lenses showed an improved reading speed of about 7% in comparison with ARC lenses on both VDU and printed chart.

Keywords: Blue Block Lenses; ARC Lenses; Reading Speed on Visual Display Unit; Printed Material

Introduction

Visible blue light, ranging from 400 to 500 nm wavelength, stimulates photosensitive retinal ganglion cells and regulates the body's circadian rhythm. But with prolonged exposure and proximity of blue light from the digital devices, melatonin secretion, a hormone that regulates the body's circadian rhythm, is found to be suppressed thus affecting the sleep quality [1-3]. Few studies have

reported these ill effects of blue light and considered it to be a new component of pollution in terms of irradiation [4].

Reading on digital devices

Reading, from any source, is a complex cognitive process deriving comprehension of the text. Reading speed and efficiency depends on various factors including contrast, luminance, legibility, font size and also the individual's motivation to read. Reading on digital electronic devices differs significantly from printed materials with regard to viewing distance, required gaze angle, and blink patterns [5,6].

Blue light and digital eye strain

Ocular symptoms of dryness, visual fatigue and asthenopia with digital use are known as digital eye strain. In the current scenario, the issue of digital eye strain has gained more interest due to increased digital usage [7-9]. This has also led to a rise in dispensing of blue block lenses with claims of increased visual performance and comfort for digital users. While some studies reported that the blue block lenses decrease the symptoms of digital eye strain [10-12], stronger clinical evidence is needed to conclude the positive impact of the blue blocking lenses on visual fatigue.

There are only a few studies performed on normal individuals comparing the blue block lenses and ARC lenses on visual performance in terms of reading speed in VDU and printed material and visual fatigue questionnaire.

Purpose of the Study

The main purpose of the study was to determine if blue block lenses could aid in improving the reading speed on VDU and reduce digital eye strain in comparison to anti reflection lenses.

Materials and Methods

This double-masked randomized controlled cross-over clinical trial with purposive sampling was conducted in 4 optometry private practice in Bengaluru and Mumbai. It included 146 healthy subjects (92 males and 54 females) aged 18 to 30 years (mean age 24.5 ± 2.5 years) satisfying the inclusion criteria. The duration of the study was August 2019 to February 2020.

The inclusion criteria were healthy individuals aged between 18 to 30 years with a refractive error of < ± 1.50DS and < ± 1.0DC BCVA 6/6, N6 and using VDU for at least two hours per day.

Subjects with any history of ocular or systemic diseases, ocular surface disorders, any contact lens wear; using any ocular or systemic drug that may induce dryness and failing the minimum binocular vision screening test battery [13] were excluded.

After written consent, the subjects were asked to read aloud the target lines from digital and printed MNRead chart, with hard coat lenses, for baseline reading speed. Time taken to read each sentence was recorded on the score sheet. Also, any words that were missed or read incorrectly were noted. A subjective visual fatigue questionnaire was administered as a baseline reference.

The subjects were then divided into two groups by randomization, a well-fitted spectacle with blue block lenses was given to the first group and ARC lenses to the second group with instruction of using it all waking hours for a week. Reading speed on digital and printed MNRead; responses to visual fatigue questionnaire were recorded after a week with respective lenses.

Participants were then given hard coated lenses on the same frame for a week to wean off any influence of previous lenses. The following week, the intervention was crossed over. Reading speed and the questionnaire response were recorded after a week of using respective lenses.

All the collected data were compiled and statistical analysis was done using ANOVA fisher's test for intercomparison.

Calculating reading speed on MNRead

The subjects were asked to read randomly all the target lines from MNRead and the time taken to read it was noted. To avoid any kind of bias, few subjects were asked to read on printed MNRead first and others on VDU first.

Reading speed (WPM) was computed for each target sentence using the following formula: 60*(10 - number of errors)/reading time [14] as instructed in the MNRead procedure.

Visual fatigue questionnaire

Digital eye strain symptoms were evaluated using a visual fatigue questionnaire taken from a study by Lin Jonathan B., *et al*. The symptom score of the baseline, blue block lenses and ARC lenses were compared for each question.

Statistical analysis

Data was recorded in Microsoft Excel 2016 and statistical analysis of the data was performed using ANOVA fisher's test with 95% Confidence interval.

Results

Comparison of WPM in printed MNRead: Mean WPM in printed MNRead on baseline was 134.095 (± 19.99) whereas with ARC lenses was 134.74 (± 17.715) and with blue block lenses was 145.126 (± 23.281). The difference between the groups were found to be statistically significant ($p < 0.001$) by using the Fisher's test (Table 1 and figure 1).

	Mean	Standard deviation	Minimum	Maximum
Base line	134.095	19.995	90.411	169.391
ARC lenses	134.741	17.715	92.046	163.189
Blue block lenses	145.126	23.281	86.026	177.793

Table 1: Mean WPM in printed MNRead chart

F = 15.017 p < 0.001vhs. (The result is significant at p < .05).

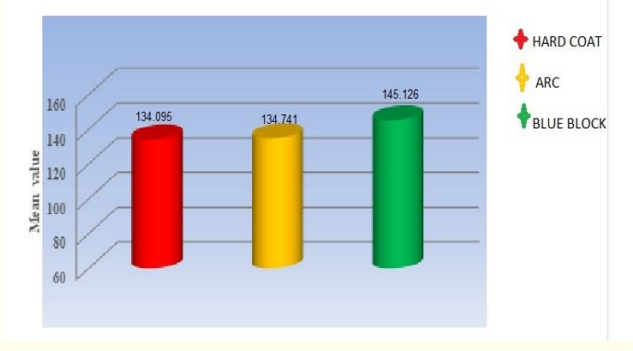

Figure 1: Mean WPM in printed MNRead chart.

Comparison of WPM in VDU digital MNRead: Mean WPM in VDU digital MNRead on baseline was 123.3 (± 27.23); while with ARC lenses was 128.3 (± 24.43) and that of blue block lenses was 136.54 (± 27.06). The difference among the groups was found to be statistically significant ($p < 0.001$) by using Fisher's test (Table 2 and figure 2).

	Mean	Standard deviation	Minimum	Maximum
Base line	123.291	27.231	59.301	180.465
ARC lenses	128.296	24.430	79.439	173.790
Blue block lenses	136.539	27.060	71.416	185.484

Table 2: Comparison of WPM in VDU digital MNRead.

F = 10.633 p < 0.001 vhs. ***(The result is significant at p < .05).

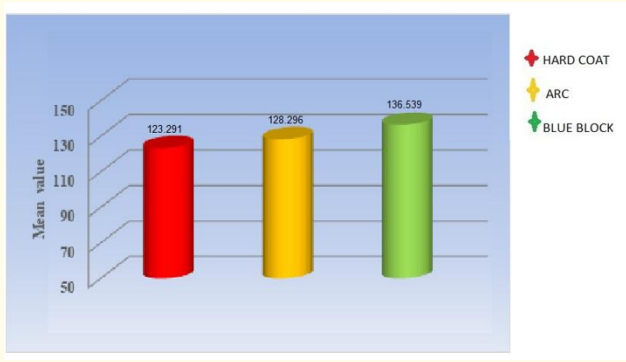

Figure 2: Comparison of WPM in VDU digital MNRead.

Visual fatigue questionnaire response: The mean score of the subjective response of each question was compared with baseline reference and both the interventions. It was found that in all the fifteen questions the mean value at the baseline was more as compared to ARC lenses and blue block lenses. In the first question the mean value at the baseline was 3.53, which proved they had the problem of eye tiredness, whereas the mean value at ARC lenses is 2.659 which showed they had moderate tiredness and at blue block lens it was 1.695 that shows tiredness was minimal.

Also, the sixth question showed at baseline as 3.25 and at blue block lenses, it was 1.405 which proves that with baseline they had eye dryness compared to ARC lenses and blue block lenses.

Subjects could feel symptomatically better in blue block lenses especially in questionnaire items (eyes feel tired, eyes feel dry and something is on my eye) compared to ARC lenses wear. The mean value showed very highly significant difference among the groups by using Fisher's test (ANOVA) (Table 3 and figure 3).

Discussion

The results from this study show an improvement of 7% in reading speed with blue block lenses on both VDU and printed material in comparison to ARC. It is found to be statistically significant. Moreover, few subjects could read finer target lines on digital MNRead with blue block lenses than with ARC lenses. This shows improved visual performance with blue block lenses subjectively, which could be attributed to improved contrast.

These findings support the findings of a study on effects of blue - blocking screen filter on accommodative accuracy and visual dis-

Questions	Baseline		ARC lenses		Blue block lenses		F
	Mean	SD	Mean	SD	Mean	SD	
1. My eyes feel tired	3.530	0.650	2.659	0.759	1.695	0.512	328.95
2. Doing computer work at home I find it hard to focus	3.082	0.859	2.29	0.751	1.506	0.528	193.35
3. I see written or computer text as blurry	2.744	0.924	2.116	0.959	1.244	0.427	142.75
4. Computer monitor looks so bright	2.872	0.979	2.091	0.876	1.372	0.485	141.56
5. Feel tired while doing computer work	2.915	1.073	2.198	1.121	1.488	0.781	82.95
6. Eyes feel dry from time to time	3.250	0.902	2.631	0.814	1.405	0.564	241.64
7. Feel as if something is on my eye	3.018	0.956	2.39	0.903	1.372	0.628	159.87
8. My neck, shoulders, Back, and lower back hurt	2.006	1.02	1.521	0.772	1.171	0.538	44.96
9. My fingers hurt	1.622	0.999	1.259	0.561	1.076	0.251	27.61
10. Feel mentally distressed	1.588	0.890	1.274	0.512	1.037	0.188	34.63
11. Feel around or inside the eyes	1.988	1.043	1.470	0.838	1.195	0.370	41.376
12. Sun's glare affects my eyes when outdoors	1.933	1.034	1.402	0.606	1.082	0.249	60.539
13. Find Fluorescent office lighting to be bothersome to the eyes	2.271	1.022	1.774	0.768	1.101	0.283	99.093
14. Eyes feel heavy	2.579	1.035	2.018	0.965	1.247	0.427	100.752
15. Eyes feel itchy	2.567	1.169	1.875	1.008	1.171	.487	91.514

Table 3: Visual fatigue questionnaire response of baseline, ARC and blue block lenses.
(The result is significant at $p < .05$).

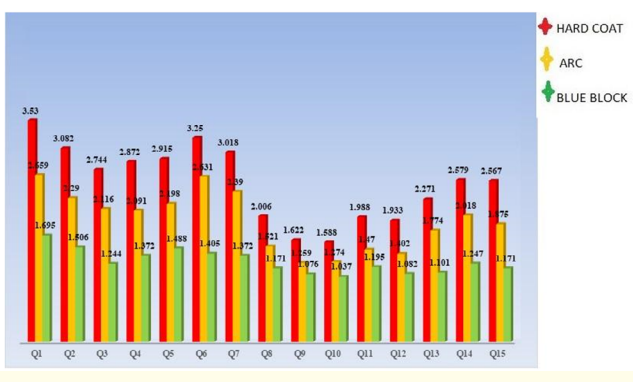

Figure 3: Visual fatigue questionnaire response of baseline, ARC and blue block lenses.

comfort, where reading speed with blue block was found to be increased by 16.5 WPM [15]. In a study by Lin Jonathan B., *et al.* on the effect of short wavelength blocking lenses on eye strain it was noted that such lenses may reduce eye strain based on physiologic correlates of eye fatigue and subjective reports of eye strain. It is also seen in our study that the subjects were symptomatically better with blue block lenses in terms of 'eyes feeling tired and dry following computer tasks'. These findings validate past studies that reported blue block lenses are more appropriate to alleviate digital eye strain and ameliorate the comfort of computer users with dry eyes. Though it does not have any significant role in improving tear production but it abates the irritation to the desiccated corneal nerve endings thus improving comfort. One possibility was the reduced blue light irradiation may also decrease irritation to the desiccated corneal nerve endings [16].

The results of this study showed high significance of the variables with blue block lenses hence the alternate hypothesis is accepted that claims the blue block lenses may reduce digital eye strain and increase reading speed in both digital and printed MN-Read in comparison to ARC lenses. The increased reading speed could be attributed to improved contrast achieved with the blue block lenses. This may suggest that the visual performance of blue block lenses could be better and helpful to those who use computers or other digital devices for longer hours. Cognitive factors were not considered while recording reading speed. Further stud-

ies may be required to factor these to relate the improved reading speed and visual performance of blue block lenses.

Conclusion

Blue block lenses enhanced the reading speed (of about 7%) in both VDU and printed chart thus provided better reading performance in comparison with ARC lenses. Blue block lenses could also alleviate digital eye strain of those who use digital devices regularly for long hours.

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