Original Article

Comparison of the Effects of Different Light Sources on Reading and Optical Performance

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ABSTRACT

Objective: To compare the effects of different light sources on reading and optical performance.
Study Design: Prospective observational study.
Place and Duration of Study: This study was conducted at the Mayo Hospital, Lahore from June 15, 2017 to December 15, 2017.
Materials and Methods: Eighty four participants (42 males and 42 females) were presented passages to read under four lighting conditions, followed by contrast assessment. Color vision was assessed with 17 Ishihara pseudo-isochromatic slides. Fifteen minutes were given for adaptation under all four lights. All the data was put in SPSS v.23 software. Data was analyzed with one way ANOVA and Friedman test. P value < 0.05 was considered statistically significant.
Results: The difference of reading rate was statistically significant ($p<0.001$) under various light sources in both male and female subjects. In males, reading rate was fastest under compact fluorescence light while in females, reading rate was fastest under light emitting diode light. One way analysis of variance with Friedman's test showed a significant relevance between visual performance and various illumination sources in males ($P <0.001$) and females ($P <0.001$)
Conclusion: We concluded that there was a significant association between reading performance and the type of illumination. Most male suggested the use of compact fluorescent light and most females suggested the use of light emitting diodes as a source of light. Tungsten bulbs were the least recommended source of light for study purpose. Fluorescent and light emitting diode lights are the suitable sources of light to perform study tasks.
Key Words: Optical performance, illumination, light sources, reading rate.

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INTRODUCTION

Various light sources have been recognized and studied as a standard for reading[1-3]. But there are some concerns and issues in the general population about the suitable light to be used for different specific tasks [4, 5]. Same light is produced by the light emitting diodes (LED) as by other bulbs, but there is less consumption of power. Light emitting diodes (LED) are both cost and energy efficient. There has been very slight concern about their influence on ocular health and visual ease. Some studies have shown that pupil size is decreased and visual acuity is improved by the scotopic rich fluorescence light source illumination. But these effects were only assessable with low-contrast stimuli which were presented briefly[6]. Some researchers further found that mood, visual performance and the participant's feeling of easy reading and visual activity was enhanced under the artificial light emitting diode lighting [7].

Nagy et al. [8] observed that visual tasks such as color and contrast perception were affected by the differences in the spectral dispersal of ambience lighting. Color chromaticity also variates with light emitting diode lighting. Mott et al.[9] performed a quasi-study to compare natural and artificial light and showed that student's reading performance was improved with the improvement of lighting conditions. Lin CC [10] found out that reading performance was much better under white light as compared to under yellow light. Light color also significantly affected visual performance. Eo IS et al.[11] used light emitting diode lamps of many colors and studied their effect on student psychology. Different colors changed the mood of art and music rooms and students' creative skills improved by this lighting modification. Light emitting diodes had a positive effect over creative skills as compared with the fluorescent light. Legge GE et al. [12] studied the reading ability of different print sizes and revealed that size of the print is of critical importance for reading clearly. Succar TA et al. [13] revealed that reading performance was significantly affected by different levels of illumination in the patients of low visual acuity.

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Fluorescent light contain low pressure mercury-vapors which use fluorescence for production of visible light. Mercury vapors are excited by the passage of electric current and short wave ultraviolet light is produced. This makes the phosphor coating on the inner surface of bulb to glow. Same mechanism enclosed in small sized tubes of the size of incandescent bulbs makes compact fluorescent light. Tungsten lamp is the one in which tungsten filaments are heated up to incandescence by the passage of electric current. Low pressure inert gas, usually argon, is filled in the glass bulb which encloses the tungsten filament. Addition of small amounts of halogen such as iodine is added to increase the intensity of light and the lamp is called tungsten-halogen lamp.

The effect of different light sources on individual reading performance and visual activity has not been studied adequately. Moreover, there is lack of regional data on different light sources. Current study is targeted at examining the influence of commonly used light source on visual activity and reading capability of individuals.

MATERIALS AND METHODS

The study was performed in Nishtar Mayo Hospital, Lahore after acquiring ethical approval from the departmental ethical committee. The duration of our study was 6 month from June 15, 2017 to December 15, 2017. Eighty four participants, half males and half females were selected using the non-consecutive random sampling technique. All the subjects were eighteen to twenty three years old and were medical students at the same hospital. Sample size was calculated using the study by Ram MS [1] as reference. Written and informed consent was taken from all the subjects. The students who has 6/6 visual acuity for far vision at a distance of six meters and N6 for near vision, no color blindness and good health were included in the study while those not meeting the inclusion criteria, recent history of ocular pathology, had refractive errors, and vitamin A deficient were excluded from our study.

This study was completed in two stages, initial examination and the investigational stage. We used a digital photometer (model-HS1010, Taiwan Tai Shi TES Company, China) to measure the intensity of light. The light sources used were (i) Compact fluorescence light (CFL), 3400-kelvin color temperature, 12 watt; (ii) Light emitting diode, 3100-kelvin color temperature, 8 watt; (iii) Fluorescent tube light, 3000-kelvin color temperature, 20 watt; (iv) Tungsten light, 3000-kelvin color temperature, 100 watt. All lights are of warm white color except tungsten light, which is a warm orange color light. The intensity of light was kept at 400 lux over all the light sources, the specific intensity picked based on many photometric values by lighting institutions, and it was checked by the digital photometer. Psychophysical analog of radiance which is known as luminance was provided by following the standards of the International Lighting Commission of Industrial Engineering (CIE) [14]. Reading time was recorded with a digital stopwatch. Reading pad was adjusted to grasp the reading material. Color vision was assessed by the use of Ishihara color vision slides and contrast was assessed by the use of Baily Lovie 10% Contrast sensitivity chart. All the participants were seated in a silent and well lighted room. The reading material for the assessment of near vision was placed at 40 cm distance from the eyes of the participants. An overhead lighting source was also arranged at 1 meter directly above the reading material. Reading passages were created which were of same readability score, in accordance with standardized psycholinguistic text readability consensus calculator software tool [15]. Text which was to be used for assessment of near vision was validated using a software. The text was presented to the participants in fifteen lines, Times New Roman, 12-points, black colored font, printed on the non-lustrous sheet of white paper. The content of the passages presented to all the participants was different but of equal readability score. The passages were presented randomly to all the participants. All the participants were asked to read the passages out loud in a closed room and were tested by the researcher himself for accuracy.

The investigational processes were executed under all lighting sources. All the participants were presented passages to read under four lighting conditions, followed by contrast assessment, after which color vision was assessed by with 17 Ishihara pseudo-isochromatic slides. Fifteen minutes were given for adaptation under all four lights. We used a closed ended questionnaire for visual performance, satisfaction level and visual ease of all the participants under all for light sources.

Table No.I: Questionnaire form

No.	Question	Yes	No
1.	Feeling of too much tearing or a desire to rub the eyes?		
2.	Experience of glare?		
3.	Experience of a burning sensation?		
4.	Double vision?		
5.	Pain in the eyes?		
6.	Confusion of color perception?		
7.	Experience of headache?		
8.	Gritty feeling in the eyes?		
9.	Tiredness of eyes?		

All the data was put in SPSS v.23 software. Reading rate, contrast sensitivity and number of color vision slides recognized were compared by applying one way ANOVA test; and visual performance was analyzed by Friedman analysis of variance. $P > 0.05$ was considered statistically insignificant.

RESULTS

In male subjects, the reading rate was 127.6±9.04 under compact fluorescence light, 118.5±11.22 under light emitting diode light, 122.1±7.44 under fluorescence light and 105.2±8.68 under tungsten light. In female subjects, , the reading rate was 125.9±8.28 under compact fluorescence light, 129.9±7.99 under light emitting diode light, 124.7±5.68under fluorescence light and 108.7±8.05 under tungsten light. The difference of reading rate was statistically significant (p<0.001) under various light sources in both male and female subjects. In males, reading rate was fastest under compact fluorescence light while in females, reading rate was fastest under light emitting diode light. Number of color vision slides which were recognized under various light sources were not statistically different in male subjects (p=0.661) and female subjects (p=0.378). In both the groups, contrast sensitivity was also comparable (p>0.05). On the other hand, one-way analysis of variance with Friedman's test showed a significant relevance between visual performance and various illumination sources in males (P <0.001) and females (P <0.001). (Table-II and III)

When all the subjects were requested to give suggestions about appropriate illumination source according to their experience of reading and visual ease, 80% of the males suggested compact fluorescence light and 75% of the females suggested light emitting diode light.

Table No.1: Comparison of Variables under Different Illumination Sources Among Male Subjects (N=42)

Variable	Compact Fluorescence Light	Light Emitting Diode Light	Fluorescence Light	Tungsten Light	p-value
Reading Rate (correct words per minute)*	127.6 ±9.04	118.5± 11.22	122.1± 7.44	105.2 ±8.68	<0. 001
Contrast sensitivity (log units)*	1±0.0	1±0.0	1±0.0	1±0.0	>0. 05
Color vision (No. of slides recognized)*	14.9± 0.76	15.1±0. 82	15.0±0. 88	15.2± 0.79	0.6 61
Visual performance**	3.7±2. 10	6.5±2.6 1	4.7±2.6 7	12.7± 3.71	<0. 001

Data is mentioned as mean ± S.D. *One way ANOVA test was applied; **Friedman test was applied.

Table No.2: Comparison of Variables under Different Illumination Sources Among Female Subjects (N=42)

Variable	Compact Fluorescence Light	Light Emitting Diode Light	Fluorescence Light	Tungsten Light	p-value
Reading Rate (correct words per minute)*	125.9± 8.28	129.9± 7.99	124.7±5. 68	108.7± 8.05	<0.0 01
Contrast sensitivity (log units)*	1±0.0	1±0.0	1±0.0	1±0.0	>0.0 5
Color vision (No. of slides recognized)*	14.9±0. 79	15.3±0. 70	15.1±0.9 4	15.1±0. 85	0.37 8
Visual performance**	3.8±2.2 8	6.9±2.3 5	5.1±2.39	12.7±2. 61	<0.0 01

Data is mentioned as mean ± S.D. *One way ANOVA test was applied; **Friedman test was applied.

DISCUSSION

We observed in our study that there was significant association between reading rate and type of illumination. In males reading rate was in following order: Compact fluorescence light>fluorescent light>light emitting diode light>tungsten light. In females, reading rate was in following order: light emitting diode light>Compact fluorescence light>fluorescent light> tungsten light. In the study by Ram MS et al. [1], similar sequence of speed of reading was observed n males, but rate was highest under fluorescent light in females and there was no significant relationship between reading rate and the type of illumination source. The results of current study in the female group are in accordance with the results of the study conducted by Yamagishi M. et al. [8]. According to them, mood, visual performance and the participant's feeling of easy reading and visual activity was enhanced under the artificial light emitting diode lighting.

In our study, we observed high visual discomfort and slow reading rate under tungsten light. But majority of the male students (80%) was satisfied with compact fluorescent lights and suggested its use whereas the majority of female students (75%) was satisfied with light emitting diode luminance and suggested its use in schools. Similarly in 2014, Eo IS et al. [11] used light emitting diode lamps of many colors and studied their effect on student psychology. Different colors changed the mood of art and music rooms and students' creative

skills improved by this lighting modification. Light emitting diodes had a positive effect over creative skills as compared with the fluorescent light. We observed that reading performance was improved under white compact fluorescence light. These results were consistent with the results of the quasi-study by Mott et al. [9] which was performed a to compare natural and artificial light and showed that student's reading performance was improved with the improvement of lighting conditions with artificial sources. Color and intensity of light affect the performance of visual tasks[17]. Best performance is under normal illumination[16]. Both low and high intensity of light affect the visual performance negatively [16, 18].

CONCLUSION

We concluded that there was a significant association between reading performance and the type of illumination. Most male suggested the use of compact fluorescent light and most females suggested the use of light emitting diodes as a source of light. Tungsten bulbs were the least recommended source of light for study purpose. Fluorescent and light emitting diode lights are the suitable sources of light to perform study tasks.

Author's Contribution:

Concept & Design of Study:	Farhan Ali
Drafting:	Hafiza Hina Rasheed
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Conflict of Interest: The study has no conflict of interest to declare by any author.

REFERENCES

1. Ram MS, Bhardwaj R. Effect of different illumination sources on reading and visual performance. J Ophthalmic Vis Res 2018;13(1):44.
2. Lin CC, Huang KC. Effects of ambient illumination conditions and background color on visual performance with TFT-LCD screens. Displays 2013;34(4):276-82.
3. Wang AH, Lin KC. Effects of display type and ambient illuminance on the comprehension performance of young and elderly readers. J Ind Product Eng 2016;33(7):443-9.
4. Zakaria SA, Bahauddin A. How do artificial lighting affects students in studying environment?: a case study of the design studio, housing building and planning, Universiti Sains Malaysia. Adv Environ Bio 2015;9(4):11-3.
5. Eo IS. LED Fiber-Optic Lighting Devices Developed for Medical Assistance for the Local Treatment Retractor 2016;17(2):666-71.
6. McColl SL, Veitch JA. Full-spectrum fluorescent lighting: a review of its effects on physiology and health. Psychol Med 2001;31(6):949-64.
7. Yamagishi M, Yamaba K, Kubo C, Nokura K, Nagata M. Effects of LED lighting characteristics on visual performance of elderly people. St Health (Gerontechnology) 2008;7(2):243.
8. Nagy BC. Visual Performance under different artificial illuminations including LEDS. 2012. FESBE Conference. http://www.ip.usp.br/congresso/images/stories/congresso/arquivos/BVNagy_Mais2autores.pdf
9. Mott MS, Robinson DH, Walden A, Burnette J, Rutherford AS. Illuminating the effects of dynamic lighting on student learning. Sage Open 2012;2(2): 2158244012445585.
10. Lin CC. Effects of illumination conditions and chromaticity contrast on reading performance. Red. 2014;40(6387):3505.
11. Eo IS, Choi KY. Study on the Effects of Learning by Changing the Color-Temperature LED Lamp. Int J Multimedia Ubiquitous Engg 2014;9(3): 309-16.
12. Legge GE, Bigelow CA. Does print size matter for reading? A review of findings from vision science and typography. J Vision. 2011;11(5):8.
13. Succar TA, Walker L, Kendrick K, Mies A, Fletcher D. Functional impact of task lighting on reading with low vision. Investig Ophthalmol Visual Sci 2015;56(7):2217-.
14. Eloholma M, et al. Mesopic models—from brightness matching to visual performance in night-time driving: a review. Lighting Res Technol 2005;37(2):155-73.
15. Software [Internet]. Readability calculator Software tool. http://www.readabilityformulas.com/ free-readability-formula-tests.php
16. Liu T, Lin CC, Huang KC, Chen YC. Effects of noise type, noise intensity, and illumination intensity on reading performance. Appl Acoust 2017;120:70-4.
17. Lin CC, Huang KC. Effects of Lighting Color, Illumination Intensity, and Text Color on Visual Performance. Int J Appl Sci Engg 2014;12(3): 193-202.
18. Lin CC. Effect of noise intensity and illumination intensity on visual performance. Percept Motor Skill 2014;119(2):441-54.