Health Scope. 2023 February; 12(1):e128709. https://doi.org/10.5812/jhealthscope-128709.

Published online 2023 March 29. **Research Article**

The Impact of Different Color Temperatures and Sources of Light on Mood and Vision: Acuity and Color Recognition

Elahe Amouzadeh [1], Seyed Abolfazl Zakerian [2], Reza Osqueizadeh [3, *], Pouria Rezasoltani [4] and Seyed Ehsan Samaei [5]

[1]Ergonomics Department, Hamadan University of Medical Sciences, Hamadan, Iran
[2]School of Public Health, Occupational Health, Tehran University of Medical Sciences, Tehran, Iran
[3]Department of Ergonomics, University of Social Welfare & Rehabilitation Sciences, Tehran, Iran
[4]Department of Statistics, University of Social Welfare & Rehabilitation Sciences, Tehran, Iran
[5]Faculty of Public Health, Mazandaran University of Medical Sciences, Sari, Iran

[*]*Corresponding author*: Department of Ergonomics, University of Social Welfare & Rehabilitation Sciences, Tehran, Iran. Email: reza.osquei@gmail.com

Received 2022 June 04; **Revised** 2023 January 09; **Accepted** 2023 February 14.

Abstract

Background: Light is a physical factor that can influence the mood and vision of people during work and study. According to the importance of these physical factors, the present study aimed to investigate the effect of the source and color temperature on the mood and vision (acuity and color recognition) of students of TUMS and USWR medical universities.
Methods: The present study is an applied study, and the research method is quasi-experimental. Twenty subjects were determined by first-type error (0.05) and test power (0.08). The mood was measured using the profile of mood states (POMS), visual acuity in different lighting conditions based on Snellen and FrACT methods, and color recognition by Ishihara's test. Data were analyzed by SPSS 22, one-way ANOVA, and Greenhouse-Geisser.
Results: The results of investigating six subscales of the POMS scale in sunlight, LED, and fluorescent with color temperatures of 4000 K and 3000 K indicated improvement in mood states ($P < 0.001$). Color recognition under different lighting conditions showed no significant difference ($P < 0.05$). However, visual acuity with the FrACT method under sunlight showed a significant difference in other lighting conditions ($P < 0.001$).
Conclusions: Light sources can influence mood and vision states (acuity and color recognition) under different lighting conditions. Therefore, using sunlight in educational environments can improve the mood and state of students.

Keywords: Illumination, Daylight Vision, Mood, Visual Acuities, LED, Fluorescence, CCT

1. Background

Among different factors that exist in workplaces, such as humidity, temperature, limited workplace, inappropriate light, noise, and dust, light is of crucial importance (1). Light, generally and specifically, is one of humans' basic physical and mental needs (2). In addition to maintaining health, this factor provides more desirable and pleasant conditions for people, and it also can create relaxation and increase outcomes in different residential, official, and industrial environments (3). Quantitative components of light such as source and corrected color temperature (CCT) are important (4, 5); "recommendation of occupational exposure limits (2016 - 2017)". Light recognition depends on the intensity, and its quality depends on the color temperature. Investigations show that different amounts of light and CCT, as two important parameters in light, create various mental and physical effects on humans (6). In addition to physiological effects, studies indicate that exposure to light surfaces with different sources and CCT can influence people's consciousness, conception, and performance (7). If the CCT is higher than 4000 K, it is cold light; if it is lower than 3000 K, it is warm light (8, 9). Corrected color temperature as a factor has an effective role in visual ergonomic parameters consistent with the functional characteristics of the person in the workplace (10). Studies reveal that CCT and light sources during working hours can influence people's consciousness, performance, and recovery (11). Some studies have shown that visual fatigue and discomfort caused by light sources can influence the body and cause pressure on the nervous system (12). Duff examined compressed fluorescent lamps used in residential areas (regarding light and color temperature) are significant health and safety aspects (13). Munch et al., emphasizing the importance of that, found that in light with a fluorescent source and lighting conditions with the temperature of 6500 Kelvin (K), the highest consciousness level, satisfaction, welfare, and visual comfort as well as immediate reaction in activities was resulted. However, fluorescent, as well as positive effects on mood and consciousness, can cause detrimental effects on mental performance. Therefore, light source and color temperature in designing artificial light, especially with fluorescent sources, is very important to satisfy visual or nonvisual requirements (14). According to Chellappa et al., indoors with desirable light can increase employees' comfort, productivity, health, and welfare (15). Lighting can make an indoor environment graceful, and also, for a learning environment, proper lighting, with the right illuminance and CCT level, can make that space pleasant and improve the mood status (16). Although some Studies, such as Knez, have demonstrated the impact of illuminance on human mood (17) and visual performance, little research has focused on the impact of the combination of these two key aspects of indoor lighting on students (18).

2. Objectives

The issue of whether CCT and light sources can act as mood inducers remain controversial and require more robust evidence, the present study aimed to investigate the effect of source (LED, fluorescent) and CCT (300, 4000 K) on mood and vision (acuity and color recognition) of students of medical universities of Tehran.

3. Methods

3.1. Participants

The present study is a quasi-experimental and within-subject study. The population of this study consisted of male and female students of Tehran and the University of Social and Welfare Rehabilitation Sciences. The sample included 20 subjects that were estimated with first-type error (0.05) and test power (0.08) based on the available non-probability sampling method (19). The inclusion criteria included 20 - 30 years old people without color blindness and visual impairments. Exclusion criteria included discomfort or any problems during the test. A stop bang score and Epworth score were used to assess the sleepiness scale, regular sleep, and sleep disorder before entering the study. A STOP-BANG score of 2 or less indicates low risk, whereas a score of 5 or higher indicates a high risk of moderate or severe obstructive sleep apnea (OSA). Score 3 or 4 to evaluate how probable they are to have OSA. So participants with scores of 2 or less entered the test.

Participants were selected from all medical students by census and interviewed by the research team via email or contact number. Then, people who were not color blind and had 10/10 vision, did not have any type of eye and head surgery, and were in the age range of 20 to 30 years on the profile of mood states (POMS) test (lower scores are expressive of people with more stable mood profiles) were joined to the study. Exclusion criteria included discomfort or any problems during the examination. The final number was selected from the selected candidates. Participants, after 5 times participations have got the reward.

3.2. Materials

The test has done in a room setting with the dimensions of 3*3 m^2 with cold and warm color LED and fluorescent lamps (36 & 20 watts) at two color temperatures of 3000 K and 4000 K And a day with sunlight. It has covered by a curtain in sunlight (Figure 1). 500 lux on a working surface at 30 degrees. Visual acuity with FrACT, Snellen visual acuity chart, POMS, color blindness, and Ishihara's test was examined. Two kinds of visual acuity tests are used software-based and physical.

3.3. Procedure

Color blindness: Ishihara's test ensured no color blindness, and the Snellen chart was used for visual examination (10.10). Profile of mood states: In this study, the mood states of students, as the first test, were administered before exposure to light. In this regard, before entering the room, the person gives numbers to his or her mood states from 0 to 4 (0-not at all, 1-to some extent, 2-average, 3-pretty much, 4-too much) by filling out a scale. This scale includes 6 subscales (stress, depression, anger, tiredness, dizziness, and power). The total score can be 0 - 200, where those between 24 and 177 have normal mood states (20). The validity and reliability of this scale were confirmed by Vaez Mousavi and Samandar in Iran (21). From the questions related to each subscale, a score is assigned to the selected option, and finally, 6 results from mood states before the study (outside the laboratory) and 6 subscales from mood states after the study (in the laboratory and under the lamp) for each type of light (each day with a different light, 5 times in 5 consecutive days, and 5 times after the entrance) will be obtained. Snellen visual acuity chart: The Snellen scale is an example of a test to measure visual accuracy. This test includes a white paper where times English letters of different sizes and thicknesses with black color are written on it. The subjects were asked to read these letters with one eye from a distance of 2.8 m. The smallest letters that the person can, as well as the fixed distance, determine the subject's ability in terms of accuracy and vision.

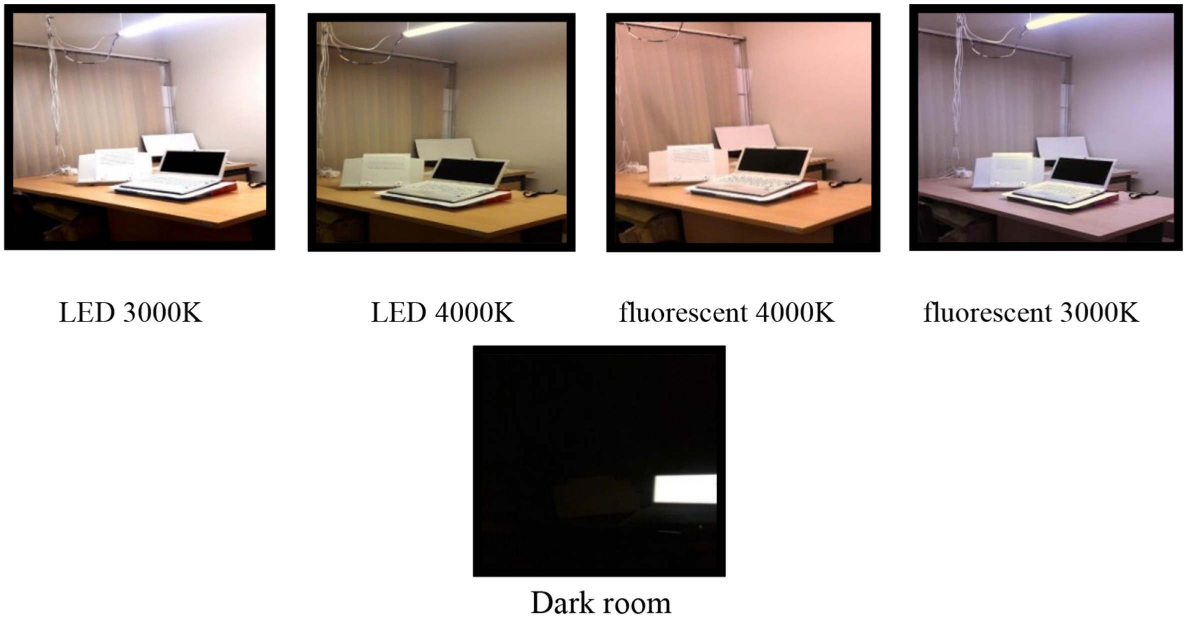

Figure 1. Different rooms' artificial light

Hashemi et al. (22) in Iran confirmed this test's validity. In this test, according to the formula, the chart was located at a distance of 2.8 m from the person on the wall due to spatial limitations. For scoring, the person read the letters from up to down loudly, and the researcher recorded the errors. This was done separately for every 5 lighting conditions. Visual acuity with FrcAT: When selecting the volunteers, this software was used in the same computer with the same angle and distance of 0.65 m that is proposed by the software, and according to the final score of the software (0.78) that indicates normal and full vision, subjects were selected. Letters C and 9 are observed at a distance of 45° from each other. The software indicates the letter C 18 times in one of the 9 directions from 6 letters; the person easily reads one. The sound of this software is turned off during the test (23), and the person presses the directions on the keyboard toward the semi-open side of the observed letter from the screen. Finally, a score was indicated by FrACT, and the score under different lighting circumstances was recorded (24). This software was created by Michael (1985). So far, this software has been used in many studies, and the last published study was conducted by Bach and Schafer (25) (Figure 2).

Scoring: A score between 0 and 0.780 was obtained from the software and recorded by the researcher. For this purpose, this was done separately for each person under 5 different conditions, and data was entered SPSS and analyzed by one-way ANOVA and Greenhouse-Geisser.

4. Results

The average age of participants was 23.20 ± (3.05), and the percentage of participants showed below (Figure 3).

The average score of the tension subscale under daylight was -4.55, with and standard deviation (SD) of 2.70; the depression subscale was -3.45, with and standard deviation of 2.37; the anger subscale was -1.6 and a standard deviation of 2.30; power subscale was -4.10 and standard deviation of 0.58, fatigue subscale was -2.85, and standard deviation of 2.32 and dizziness subscale was -1.95 and standard deviation of 1.58 (Table 1).

The results of one-way ANOVA showed that average subscales of stress, depression, anger, power, fatigue, and dizziness are different at least in two lighting conditions (Table 2).

According to the results, the means of subscales were compared under different conditions. The results showed that a significant difference exists between the average score of stress subscale under daylight with LED 3000 K and 4000 K and fluorescent 3000 K and 4000 K significant A significant difference exists between LED 3000 K and LED 4000 K, but no difference exists between fluorescent. A significant difference exists between LED & fluorescent 4000 K and fluorescent 3000 K and 4000 K (Table 3).

The results of visual acuity analysis in the Snellen chart showed that by investigating the probability, the average error in 5 lighting conditions showed no significant differ-

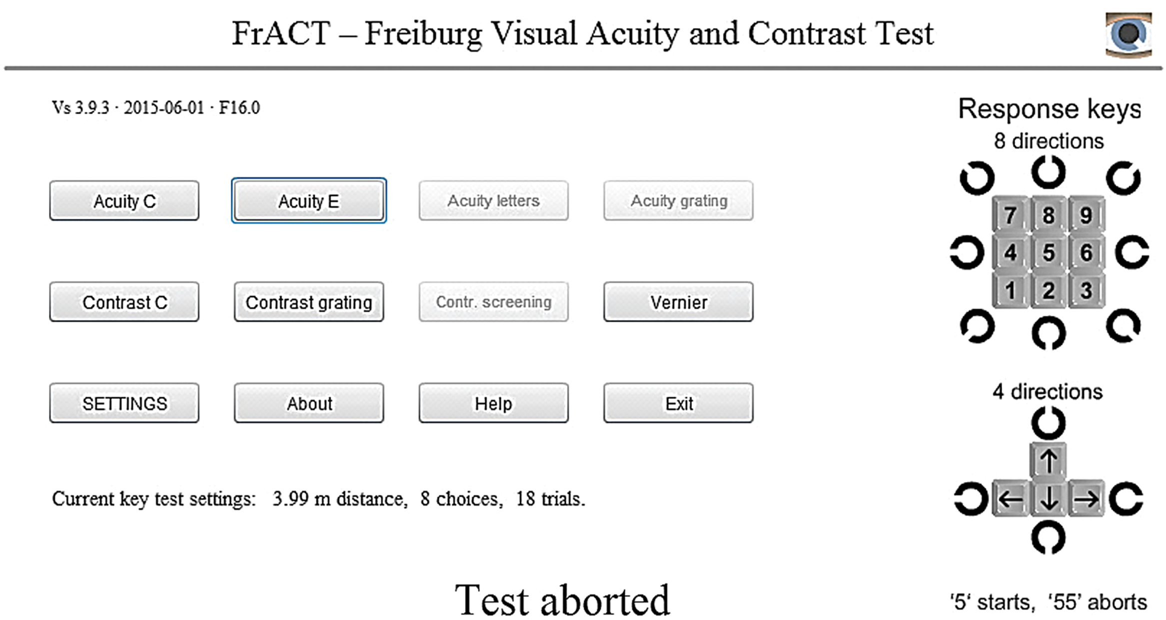

Figure 2. FrACT test software

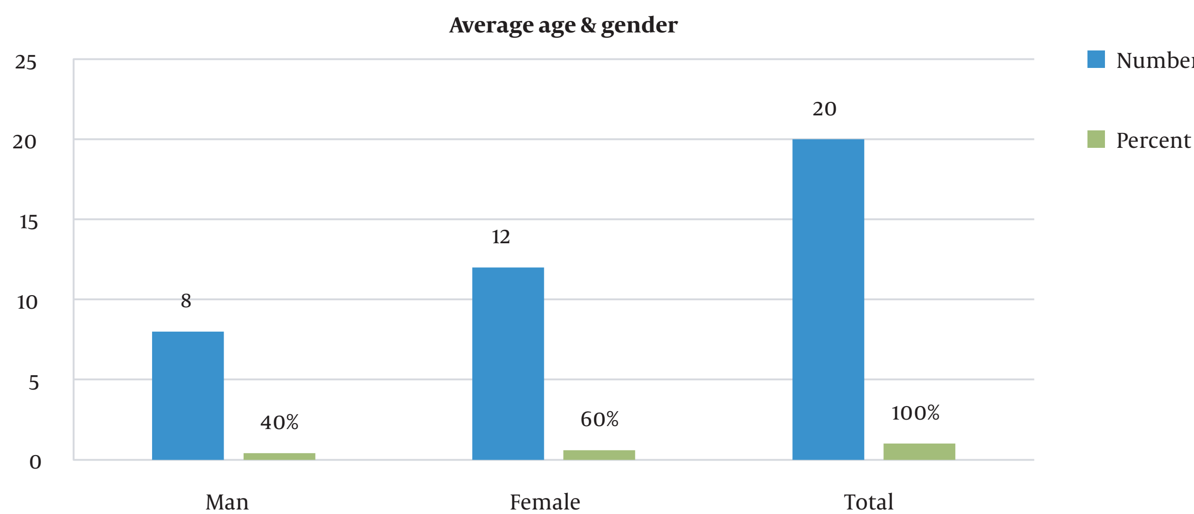

Figure 3. Average age and gender

ence. Also, the analysis of visual acuity in FrACT with the probability of ($P < 0.001$) showed that at least two mean values are different (Table 4).

A pairwise comparison of visual acuity based on the software method showed that a significant difference existed between visual acuity obtained from FrACT under daylight with LED 3000 K and 4000 K and fluorescent 4000 K and 3000 K.

Pairwise comparison of visual acuity based on the software method showed that no significant difference existed between visual acuity obtained from FrACT under LED 3000 K with LED 4000 K and fluorescent 4000 K and 3000 K and LED 4000 K with fluorescent 4000 K and 3000 K and fluorescent 3000 K with fluorescent 4000 K. The results of

Table 1. The Average Score of 6 Subscales Under Daylight, LED, Fluorescent [a]

Subscale and Group	Mean ± SD
Tension	
1	-4.55 ± 2.70
2	1. 80 ± 1.28
3	-2.45 ± 1.95
4	3.4 ± 3.74
5	0.75 ± 3.38
Depression	
1	-3.45 ± 2.37
2	1.90 ± 1.74
3	-2.95 ± 2.16
4	3.55 ± 0.99
5	-1.15 ± 2.85
Anger	
1	-1.6 ± 2.30
2	2.15 ± 2.99
3	-1.15 ± 2.85
4	2.25 ± 3.10
5	-0.65 ± 1.08
Power	
1	4.10 ± 0.584
2	1.95 ± 0.583
3	1.50 ± 0.569
4	5 ± 0.62
5	1.65 ± 0.708
Fatigue	
1	-2.85 ± 2.32
2	0.85 ± 2.30
3	-2.35 ± 2.13
4	2.75 ± 2.35
5	2 ± 1.74
Dizziness	
1	-1.95 ± 1.583
2	0.45 ± 2.064
3	-2.25 ± 1.681
4	2.40 ± 1.142
5	1.25 ± 1.773

Abbreviation: SD, standard deviation.
[a] Daylight, LED 3000 K, LED 4000 K, fluorescent 3000 K, fluorescent 4000 K named 1 to 5.

the color recognition analysis average correct responses to Ishihara paper lighting conditions showed no significant difference ($P < 0.05$) (Table 5).

5. Discussion

The findings showed that decreased stress in daylight was higher than in four artificial sources ($P < 0.001$). Kilic and Hasirci showed that the employment of sunlight in the library could increase students' interest and positively influence their participation (26). Sunlight creates positive behavioral and physiological changes (27).

In this regard, Sami Abdelaziz Mahmoud et al. found that sunlight effectively increases cognitive performance, health improvement, and mental welfare (28). Mayhoub and Rabboh pointed to the achievement of pleasant mental feelings and decreased stress due to exposure to the sun (29). The results of the present study showed that decreased depression under daylight is higher than four artificial sources, but compared with LED with a color temperature of 4000 K, no significant difference was observed ($P > 0.05$). Shin et al. (30) showed that exposure to daylight could improve mental processes such as happiness, mood, and consciousness and decrease stress levels. Kaida et al. (31) believe that sunlight is an effective strategy for decreasing depression and improving mood states. According to the findings by Ekstrom and Beaven (32), daylight, compared with artificial light, has a more stable impact on happiness and consciousness; according to the findings of this study, anger levels at high color temperatures decreased, and at low color, temperatures decreased. Ekstrom and Beaven (32) found that exposure to high-color light causes neural stability and decreases anger. According to the findings by Munch et al. (14), in light of a fluorescent source and lighting conditions with a temperature of 6500 K, the highest welfare and comfort levels resulted in performing the related activities. According to Kaida et al. (31), exposure to daylight enhances a positive sensational-emotional state. The power level to perform activities under daylight is higher than in artificial light. Fluorescent in the lower age range activates this feeling better, making it suitable for children. de Kort and Smolders stated that increased light intensity creates more energy and limits reaction time (7) Knez found that exposure to high-frequency light causes more readiness for problem-solving (33).

Decreased fatigue in LED 4000 K is higher than in LED 3000 K. This result was similar in fluorescent. In other words, fatigue in higher color temperatures decreased more. The results of a study by Hawes et al. (34) showed that the higher the color temperature of light sources, the lower mental fatigue will exist, which is consistent with the present study's findings. Canazei et al. (35) found that the mental fatigue rate in fluorescent is higher than in LED, accompanied by a slower response. A study by de Kort and

Table 2. Average of Mood Subscales Under Different Conditions

Subscale	Mauchly's Test of Sphericity		Degrees of Freedom	F Factor	Mean Squared	Sig
	Statistics	P-Value				
Tension [a]	0.45	0.127	4	-	209.235	0.001 <
Depression [b]	0.343	0.029	2.888	40.962	258.021	0.001 <
Anger [b]	0.225	0.002	2.085	14.774	98.311	0.001 <
Power [a]	0.415	0.084	4	-	51.285	0.001 <
Fatigue [b]	0.323	0.021	3.024	21.061	154.345	0.001 <
Dizziness [a]	0.509	0.229	4	-	73.240	0.001 <

[a] One-way ANOVA was used for analysis.
[b] Greenhouse-Geisser was used for analysis.

Table 4. Comparison of Visual Acuity Comparison, Software-Based (FrACT) and Snellen Chart

Visual Acuity	Mauchly's Test of Sphericity		Degrees of Freedom	F Factor	Mean Squared	Sig
	Statistics	P-Value				
Software [a]	0.0	0.117	4	-	0.0	< 0.001
Snellen chart [b]	0.318	0.019	2.573	1.019	0.443	0.384

[a] One-way ANOVA was used for analysis.
[b] Greenhouse-Geisser was used for analysis.

Table 5. Means Compared Under Different Color Recognition Conditions

Color Recognition	Mauchly's Sphericity Test		df	F Factor	Mean's Squared	P-Value
	Statistic	Sig				
Software [a]	0.663	0.624	4	1.049	0.225	0.388

[a] One-way ANOVA was used for analysis.

Smolders (7) indicates that fatigue levels while exposed to daylight during the morning are rarely reported.

Sithravel et al. found that 1000 K during the morning and afternoon helps people to confound fatigue and enhance consciousness during the day. On the other hand, daylight with high power can create more physiological energy and arousal compared with low intensity (36). According to the findings of this study, decreased dizziness under LED with a color temperature of 4000 K was higher than in daylight. LED at 4000 K caused more dizziness than the other three light sources. Smolders and de Kort showed that the white color and the source could increase consciousness and decrease dizziness (37). Lee et al. found that those exposed to high color temperatures rarely feel dizzy and are more cheerful and happy (38). The present study showed that high color temperatures in LED and fluorescent sources could improve vision if other environmental and lighting conditions are stable ($P < 0.05$). LED lamps, unlike fluorescent lamps, can be effective for those with visual impairments, which is evident in high color (39). However, in this study, visual acuity from FrACT due to the color proximity of four light sources showed no significant difference between fluorescent and LED. The results of the color recognition test indicated that healthy participants in this study did not affect by the light source and color temperature, and no significant difference existed between average and correct responses to Ishihara papers. Studies that investigate the effect of color on feelings should ensure the visual integrity of people in this environment (40).

5.1. Conclusions

Compared with artificial sources, daylight in different subscales of mood states and visual acuity positively affects activities, but it does not influence color recognition. Among artificial sources, two light sources (LED and fluorescent) with a color temperature of 4000 K compared with 3000 K and among LED and fluorescent with the same LED colors improved the mood state of people, but the light source did not influence visual acuity and color recognition. The results showed that the employment of sunlight and artificial LED light with a color temperature significantly impacts pupils' moods. Because mood can be influenced by every country's environmental and cultural factors and affect behavior and other individual functions, this issue is probably important in choosing the right source for specific training locations. For the first time, this study was conducted in Iran to improve lighting conditions as one of the important environmental factors affecting students' mood and vision at TUMS and USWR universities of medical sciences. The employed artificial light was taken from color temperatures of 3000 and 4000 K and used in two popular sources, LED and fluorescent.

5.2. Limitations

The number of participants, since every person should attend 5 times and persuading participants to attend every single day to order the lighting equipment from other countries and postpone the time of the project

5.3. Suggestions

Other environmental factors were the same for all participants.

Future studies could choose a wide range of ages and numbers of people in various fields. And also, the CTs was so close to each other seems too difficult to distinguish. Try to test new lighting technology simultaneous is broadly classified mainly into four types of lighting; incandescent, fluorescent, halogen, LED (light emitting diode).

Acknowledgments

The authors would like to acknowledge the Department of Ergonomics, the University of USWR, and the Ergonomics laboratory, for their support and contribution to this study. It was controlled by the ethics committee of the Ergonomics Department of USWR University (December 19, 2017).

Footnotes

Authors' Contribution: SA. Z. conceived and designed the evaluation for my master's thesis. E. A. and R. O. participated in designing the evaluation and helped to draft the manuscript. E. A. revised manuscript and P. RS. performed the statistical. E. A. collected the clinical data, interpreted them, and revised the manuscript. SE. S. revised the final manuscript. All authors read and approved the final manuscript.

Conflict of Interests: We declare no conflicts of interest related to the funding or support of this research. The research was conducted as part of a master's thesis, and there was no financial research support from universities or companies for the authors.

Ethical Approval: This study does not involve any interventional actions on humans or patients, and the rights and welfare of the participants have been protected through ethical considerations addressed by the USWR research committee.

Funding/Support: There were no financial aides from any department.

Informed Consent: It was not declared by the authors.

References

1. Abboushi B, Elzeyadi I. The Relationship between Sunlight Pattern Geometry and Visual Comfort in Daylit Offices.In: Jarrett C, Plowright P, Rashed-Ali H, editors. *ARCC-EAAE 2018 International Conference Hosted by Temple University in Partnership with Jefferson University and Drexel University*. 16-19 May 2018; Philadelphia, PA, United States. 2018.
2. Marhavilas P, Koulouriotis D, Nikolaou I, Tsotoulidou S. International Occupational Health and Safety Management-Systems Standards as a Frame for the Sustainability: Mapping the Territory. *Sustainability*. 2018;**10**(10):3663. https://doi.org/10.3390/su10103663.
3. Altomonte S, Allen J, Bluyssen PM, Brager G, Heschong L, Loder A, et al. Ten questions concerning well-being in the built environment. *Build Environ*. 2020;**180**:106949. https://doi.org/10.1016/j.buildenv.2020.106949.
4. Durmus D. Correlated color temperature: Use and limitations. *Light Res Technol*. 2022;**54**(4):363–75. https://doi.org/10.1177/14771535211034330.
5. Rea MS; Illuminating Engineering Society of North America. *The IESNA Lighting Handbook: Reference & Application*. New York: Illuminating Engineering Society of North America; 2000.
6. Huang RH, Lee L, Chiu YA, Sun Y. Effects of correlated color temperature on focused and sustained attention under white LED desk lighting. *Color Res Appl*. 2015;**40**(3):281–6. https://doi.org/10.1002/col.21885.
7. de Kort YAW, Smolders K. Effects of dynamic lighting on office workers: First results of a field study with monthly alternating settings. *Light Res Technol*. 2010;**42**(3):345–60. https://doi.org/10.1177/1477153510378150.
8. Van Winkle G. *Manually controllable LED correlated color temperature light fixture*. 2018. Available from: https://patents.google.com/patent/US10091855B2/en.
9. Knez I. Effects of Colour of Light on Nonvisual Psychological Processes. *J Environ Psychol*. 2001;**21**(2):201–8. https://doi.org/10.1006/jevp.2000.0198.
10. Anshel JR. Visual ergonomics in the workplace. *AAOHN J*. 2007;**55**(10):414–20. quiz 421-2. [PubMed ID: 17969539]. https://doi.org/10.1177/216507990705501004.
11. Hoffmann G, Gufler V, Griesmacher A, Bartenbach C, Canazei M, Staggl S, et al. Effects of variable lighting intensities and colour temperatures on sulphatoxymelatonin and subjective mood in an experimental office workplace. *Appl Ergon*. 2008;**39**(6):719–28. [PubMed ID: 18164275]. https://doi.org/10.1016/j.apergo.2007.11.005.
12. Gabel V, Maire M, Reichert CF, Chellappa SL, Schmidt C, Hommes V, et al. Effects of artificial dawn and morning blue light on daytime cognitive performance, well-being, cortisol and melatonin levels. *Chronobiol Int*. 2013;**30**(8):988–97. [PubMed ID: 23841684]. https://doi.org/10.3109/07420528.2013.793196.
13. Duff JT. An Examination Into the Use of Compact Fluorescent Lamps in the Domestic Environment. *J Sustain Des Appl Res*. 2012;**1**(1):7.

14. Munch M, Linhart F, Borisuit A, Jaeggi SM, Scartezzini JL. Effects of prior light exposure on early evening performance, subjective sleepiness, and hormonal secretion. *Behav Neurosci*. 2012;**126**(1):196–203. [PubMed ID: 22201280]. https://doi.org/10.1037/a0026702.
15. Chellappa SL, Steiner R, Blattner P, Oelhafen P, Gotz T, Cajochen C. Non-visual effects of light on melatonin, alertness and cognitive performance: can blue-enriched light keep us alert? *PLoS One*. 2011;**6**(1). e16429. [PubMed ID: 21298068]. [PubMed Central ID: PMC3027693]. https://doi.org/10.1371/journal.pone.0016429.
16. Vasquez NG, Amorim CND, Matusiak B, Kanno J, Sokol N, Martyniuk-Peczek J, et al. Lighting conditions in home office and occupant's perception: Exploring drivers of satisfaction. *Energy Build*. 2022;**261**:111977. https://doi.org/10.1016/j.enbuild.2022.111977.
17. Knez I. Effects of indoor lighting on mood and cognition. *J Environ Psychol*. 1995;**15**(1):39–51. https://doi.org/10.1016/0272-4944(95)90013-6.
18. Zhu Y, Yang M, Yao Y, Xiong X, Li X, Zhou G, et al. Effects of Illuminance and Correlated Color Temperature on Daytime Cognitive Performance, Subjective Mood, and Alertness in Healthy Adults. *Environ Behav*. 2019;**51**(2):199–230. https://doi.org/10.1177/0013916517738077.
19. Zamani MA, Osqueizadeh R, Tabatabai Ghomshe SF. [Ergonomic Assessment of Persian Font Typography]. *Iran J Ergon*. 2014;**2**(2):20–8. Persian.
20. Kendig MD, Morris MJ. Fizzing out: No effect of acute carbohydrate consumption on mood. *Neurosci Biobehav Rev*. 2019;**104**:56–7. [PubMed ID: 31265871]. https://doi.org/10.1016/j.neubiorev.2019.06.028.
21. Vaez Mousavi SMK, Samandar GR. [Norm of POMS for elites athletes of seven sport]. *Olympic*. 2003;**10**(3-4):5–18. Persian.
22. Hashemi H, Yekta A, Jafarzadehpur E, Ostadimoghaddam H, Asharlous A, Nabovati P, et al. Sensitivity and Specificity of Preschool Vision Screening in Iran. *Iran J Public Health*. 2017;**46**(2):207–15. [PubMed ID: 28451556]. [PubMed Central ID: PMC5402779].
23. Tavassoli T, Latham K, Bach M, Dakin SC, Baron-Cohen S. Psychophysical measures of visual acuity in autism spectrum conditions. *Vision Res*. 2011;**51**(15):1778–80. [PubMed ID: 21704058]. [PubMed Central ID: PMC6345362]. https://doi.org/10.1016/j.visres.2011.06.004.
24. Bach M. The Freiburg Visual Acuity Test-variability unchanged by post-hoc re-analysis. *Graefes Arch Clin Exp Ophthalmol*. 2006;**245**(7):965–71. [PubMed ID: 17219125]. https://doi.org/10.1007/s00417-006-0474-4.
25. Bach M, Schafer K. Visual Acuity Testing: Feedback Affects Neither Outcome nor Reproducibility, but Leaves Participants Happier. *PLoS One*. 2016;**11**(1). e0147803. [PubMed ID: 26824693]. [PubMed Central ID: PMC4732607]. https://doi.org/10.1371/journal.pone.0147803.
26. Kilic DK, Hasirci D. Daylighting Concepts for University Libraries and Their Influences on Users' Satisfaction. *J Acad Librariansh*. 2011;**37**(6):471–9. https://doi.org/10.1016/j.acalib.2011.07.003.
27. Kong Z, Liu Q, Li X, Hou K, Xing Q. Indoor lighting effects on subjective impressions and mood states: A critical review. *Build Environ*. 2022;**224**:109591. https://doi.org/10.1016/j.buildenv.2022.109591.
28. Sami Abdelaziz Mahmoud N, El Samanoudy G, Jung C. Simulating the natural lighting for a physical and mental Well-being in residential building in Dubai, UAE. *Ain Shams Eng J*. 2023;**14**(1):101810. https://doi.org/10.1016/j.asej.2022.101810.
29. Mayhoub MS, Rabboh EH. Daylighting in shopping malls: Customer's perception, preference, and satisfaction. *Energy Build*. 2022;**255**:111691. https://doi.org/10.1016/j.enbuild.2021.111691.
30. Shin YB, Woo SH, Kim DH, Kim J, Kim JJ, Park JY. The effect on emotions and brain activity by the direct/indirect lighting in the residential environment. *Neurosci Lett*. 2015;**584**:28–32. [PubMed ID: 25281545]. https://doi.org/10.1016/j.neulet.2014.09.046.
31. Kaida K, Takeda Y, Tsuzuki K. The relationship between flow, sleepiness and cognitive performance: the effects of short afternoon nap and bright light exposure. *Ind Health*. 2012;**50**(3):189–96. [PubMed ID: 22453206]. https://doi.org/10.2486/indhealth.ms1323.
32. Ekstrom JG, Beaven CM. Effects of blue light and caffeine on mood. *Psychopharmacology (Berl)*. 2014;**231**(18):3677–83. [PubMed ID: 24590053]. https://doi.org/10.1007/s00213-014-3503-8.
33. Knez I. Affective and cognitive reactions to subliminal flicker from fluorescent lighting. *Conscious Cogn*. 2014;**26**:97–104. [PubMed ID: 24685568]. https://doi.org/10.1016/j.concog.2014.02.006.
34. Hawes BK, Brunyé TT, Mahoney CR, Sullivan JM, Aall CD. Effects of four workplace lighting technologies on perception, cognition and affective state. *Int J Ind Ergon*. 2012;**42**(1):122–8. https://doi.org/10.1016/j.ergon.2011.09.004.
35. Canazei M, Pohl W, Bliem HR, Weiss EM. Acute effects of different light spectra on simulated night-shift work without circadian alignment. *Chronobiol Int*. 2017;**34**(3):303–17. [PubMed ID: 27579732]. https://doi.org/10.1080/07420528.2016.1222414.
36. Sithravel R, Ibrahim R, Lye MS, Perimal EK, Ibrahim N, Dahlan ND. Morning boost on individuals' psychophysiological wellbeing indicators with supportive, dynamic lighting in windowless open-plan workplace in Malaysia. *PLoS One*. 2018;**13**(11). e0207488. [PubMed ID: 30496193]. [PubMed Central ID: PMC6264480]. https://doi.org/10.1371/journal.pone.0207488.
37. Smolders KCHJ, de Kort YAW. Bright light and mental fatigue: Effects on alertness, vitality, performance and physiological arousal. *J Environ Psychol*. 2014;**39**:77–91. https://doi.org/10.1016/j.jenvp.2013.12.010.
38. Lee JK, Koh AC, Koh SX, Liu GJ, Nio AQ, Fan PW. Neck cooling and cognitive performance following exercise-induced hyperthermia. *Eur J Appl Physiol*. 2014;**114**(2):375–84. [PubMed ID: 24318656]. https://doi.org/10.1007/s00421-013-2774-9.
39. Bustamante P, Acosta I, León J, Campano MA. Assessment of Color Discrimination of Different Light Sources. *Buildings*. 2021;**11**(11):527. https://doi.org/10.3390/buildings11110527.
40. Sokolova M, Fernández-Caballero A. A Review on the Role of Color and Light in Affective Computing. *Appl Sci*. 2015;**5**(3):275–93. https://doi.org/10.3390/app5030275.

Table 3. Six Subscales of Mood Means Compared Under 5 Conditions

Subscale	Group 1	Group 2	Standard Deviation	P-Value
Tension	Daylight	LED 3000 K	1.54	0.001>
		LED 4000 K	1.053	0.004
		Fluorescent 3000 K	0.64	0.001>
		Fluorescent 4000 K	0.76	0.001>
	LED 3000 K	LED 4000 K	0.88	0.001>
		Fluorescent 3000 K	0.88	0.078
		Fluorescent 4000 K	0.64	0.25
	LED 4000 K	Fluorescent 3000 K	0.8	0.001>
		Fluorescent 4000 K	0.91	0.001
	Fluorescent 3000 K	Fluorescent 4000 K	1.22	0.044
Depression	Daylight	LED 3000 K	0.658	0.001>
		LED 4000 K	0.635	0.44
		Fluorescent 3000 K	0.628	0.001>
		Fluorescent 4000 K	0.865	0.015
	LED 3000 K	LED 4000 K	0.464	0.001>
		Fluorescent 3000 K	0.449	0.002
		Fluorescent 4000 K	0.738	0.001
	LED 4000 K	Fluorescent 3000 K	0.427	0.001
		Fluorescent 4000 K	0.878	0.055
	Fluorescent 3000 K	Fluorescent 4000 K	0.637	> 0.001
Anger	Daylight	LED 3000 K	0.721	> 0.001
		LED 4000 K	0.769	0.65
		Fluorescent 3000 K	0.734	0.001
		Fluorescent 4000 K	0.651	0.16
	LED 3000 K	LED 4000 K	0.74	> 0.001
		Fluorescent 3000 K	0.25	0.69
		Fluorescent 4000 K	0.702	> 0.001
	LED 4000 K	Fluorescent 3000 K	0.769	> 0.001
		Fluorescent 4000 K	0.613	0.42
	Fluorescent 3000 K	Fluorescent 4000 K	0.721	> 0.001
Power	Daylight	LED 3000 K	0.719	0.008
		LED 4000 K	0.762	0.003
		Fluorescent 3000 K	0.836	0.295
		Fluorescent 4000 K	0.78	0.005
	LED 3000 K	LED 4000 K	0.545	0.419
		Fluorescent 3000 K	0.776	0.001
		Fluorescent 4000 K	0.465	0.527
	LED 4000 K	Fluorescent 3000 K	0.881	0.001
		Fluorescent 4000 K	0.455	0.745

	Fluorescent 3000 K	Fluorescent 4000 K	0.868	0.001
Fatigue	Daylight	LED 3000 K	0.633	> 0.001
	LED 3000 K	LED 4000 K	0.69	0.478
	LED 4000 K	Fluorescent 3000 K	0.832	> 0.001
	Fluorescent 3000 K	Fluorescent 4000 K	0.591	0.166
Dizziness	Daylight	Led 3000 K	0.455	> 0.001
	LED 3000 K	LED 4000 K	0.378	0.437
	LED 4000 K	Fluorescent 3000 K	0.499	> 0.001
	Fluorescent 3000 K	Fluorescent 4000 K	0.546	0.001