Original Article

Light Exposure in Young University Students: Effect on Ocular Surface Health

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ABSTRACT

Purpose: The ocular surface is the first structure to absorb light and transfer it to retina to form images. However, the effect of different wavelengths and light exposure timing could harm the eye. The current study aims to measure light exposure and its correlation to the ocular surface.

Study Design: Cross sectional observational.

Place and Duration of Study: Qassim University, from March to September 2023.

Methods: Light sensor buttons (RGB) were used in the current study (LYS technologies); 53 subjects were asked to wear them on the collar for one week, followed by a visit to the optometry clinic for an eye examination by bio-microscopy and Schirmer I test. Consequently, readings from Kerato-graph 5M were obtained. Lastly, participants were asked to fill out a validated Arabic OSDI questionnaire.

Results: Results of the dry eye symptoms scale revealed that 24.5% had mild symptoms, and 20.8% of participants reported severe dry eye symptoms. A negative correlation between the Schirmer test and OSDI scores was found. Blue light exposure at night was negatively correlated to tear meniscus height ($P < 0.05$). Moreover, tear meniscus height was lower in participants with higher exposure to the red component of light during the day and higher melanotic lux in the daytime ($P<0.05$). Tear breakup time was lower in patients exposed to higher melanopic lux during nighttime ($p<0.05$).

Conclusion: Light exposure habits are associated with some dry eye parameters. Moreover, light at night, especially melanopic lux wave-length is a risk factor for developing dry eye disease.

Key Words: Lux, Dry eye, Meniscus, Wave length, Tear.

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INTRODUCTION

The ocular surface, consisting of the cornea, conjunctiva and tear film, is essential for optimal visual function and ocular health. Ocular surface diseases can cause irritation, visual disturbances, and decreased quality of life.[1,2] Accurately diagnosing and comprehending these diseases necessitates a comprehensive evaluation that combines patient-reported symptoms with objective measurements of signs using various tests.[3] A widely used questionnaire for evaluating the symptoms of ocular surface disease is the Ocular Surface Disease Index (OSDI). It has 12 questions intended to gauge the frequency of symptoms and how they affect daily duties, including reading, traveling, and doing visual tasks.[4]

The OSDI questionnaire is divided into three sections that address the frequency of symptoms, how they affect day-to-day activities, and how environmental factors may affect the ocular surface.[5,6] Recently study of how light exposure affects eye health has gained popularity especially among young adults.[7,8] Both natural and artificial light are necessary to regulate many physiological processes, including circadian cycles and visual function. However, excessive or insufficient light exposure has been associated with the onset or progression of ocular surface diseases, such as dry eye syndrome. Understanding the relationship between light exposure and ocular health is crucial as the adult population is frequently exposed to prolonged screen time, increased use of electronic devices, and changing environmental conditions.[9,10] Investigating how light exposure affects the surface of the eyes might provide insight into possible interventions and preventative measures to lessen the harmful effects and maintain eye health. Prior studies on sunlight in Qassim region of Saudi Arabia showed that a sizable fraction of the populace received little to no daily sun exposure.[11] The study Naeem et al, revealed that 79.5% of residents had an average daily UV exposure of less than 15 minutes, as determined by subjective questionnaires. With the advancement of technology, however, wearable devices such as smart-watches and wrist activity monitors have acquired popularity among a large number of people, including the Saudi Arabian populace. This increased use of sensor-embedded wearables can be attributed to the expanding health and fitness consciousness in the nation.[12,13] Various objective out-of-the-laboratory devices have emerged in the market. These devices can measure light exposure more accurately and objectively.[14] Despite availability of such devices, there is lack of studies investigating light exposure, specifically in the Saudi Arabian population.

The purpose of this study was to investigate how light exposure affects the ocular health of young adults living in the Saudi Arabian region of Al-Qassim. This project aims to gather objective and quantitative data about the amount and patterns of light exposure individuals experience in their daily lives, as well as the impact of light exposure on the ocular surface, by deploying wearable sensors that can measure light exposure.

METHODS

Fifty-three participants between the age of 18 and 28 years were included in this study. Individuals who had undergone ocular surgeries in the past, used sleeping aids or worked in night shifts were excluded. Informed consent was taken making sure Declaration of Helsinki was strictly followed. The study was approved by Qassim University institutional review board.

All participants underwent an ocular surface examination by slit lamp bio-microscopy to exclude any disease that could affect the current study. Every participant was requested to complete the Ocular Surface Disease Index (OSDI-ARB), which Bakkar et al, (2021) translated into Arabic.[15]

Following the completion of questionnaire, participants used the Keratograph 5M instrument to undergo ocular surface imaging. Images of the inferior tear meniscus height (TMH) were taken from each participant, and the measurement was made at the central location in relation to the pupil center, perpendicular to the lid margin.[16] An integrated ruler made this measurement easier. The stability of the tear film was evaluated by measuring the noninvasive tear breakup time (NIKBUT). The time interval known as NIKBUT is the length of time that passes between a blink and the tear film's placid rings breaking. The average NIKBUT value was made more accessible using the Keratograph 5M equipment, which provided a numerical evaluation of tear film stability. Meibography was a method used to assess the upper and lower eyelids after eversion. It used the infrared Meibography model of the Keratograph 5M.[4] R scan software was used to measure conjunctival redness. Conjunctival redness was objectively classified into four degrees, from 0 to 3. The Keratograph 5M instrument was used to photograph the subjects' ocular surface after they had finished answering the questionnaire. The imaging technique was designed to get images of inferior tear meniscus height (TMH). The integrated ruler was positioned at the central point about the pupil center, perpendicular to the lid margin, to acquire this measurement.

All subjects underwent the Schirmer I test following the ocular surface examination using the Keratograph 5M.[17] This examination assessed the amount of tears produced by the lacrimal glands and quantified their production. A conventional Schirmer strip measuring 5 × 40mm was positioned at the intersection of the inferior eyelid center and outer thirds. After five minutes of eye closure, the moist area of the strip—which represents the amount of tears absorbed—was measured.

The LYS button is a wearable gadget that uses an RGB sensor to assess light consumption. The LYS Insight app collects data automatically every 15 seconds on a variety of light metrics, including kelvin, lux, melanopic lux (mEDI) readings, and the content of red, green, and blue light. Participants were instructed to wear the device as a button that was close to their eyes, as on a collar, in order to collect this data. While they slept, the gadget stayed by their bedside to observe constantly. Bluetooth connectivity linked the device to participants' phones, allowing information to be transmitted to a data collection portal accessible to the investigator via the LYS Company. Additionally, the device utilized GPS connectivity to determine the timing of sunrise and sunset. The participants were equipped with light sensor buttons (LYS) for seven consecutive days. These sensors collected light data every 15 seconds, which was then automatically transmitted to an online portal and exported into individual Excel sheets for each participant. The data gathered included measurements of light input in Kelvin, light intensity in lux, and the red, green, and blue components of light measured in $W/m^2/nm$. Only participants who wore the LYS buttons for a minimum of five days were included in the data analysis.

Data was edited and prepared in Excel sheets and analyzed using SPSS version 25. Frequency, percentages, and graphs were used for categorical variables. The mean, median, SD, and IQR were used to describe quantitative variables. To investigate the direction and intensity of associations between the research variables, Pearson and Spearman correlations were performed. P-values of 0.05 or less were regarded as significant.

RESULTS

Average age of the participants was 22.8 ± 1.58 years with 69.8% males. Distribution of severity of dry symptoms using the OSDI questionnaire revealed that 49.1% of participants were average, 24.5% had mild symptoms, and 20.8% of participants reported severe dry eye symptoms.

The average TMH of right and left eyes was 0.28 ± 0.06, and the NIKBUT mean was 12.2 ± 4.7 SD. Eighty percent participants had average interferometry, 2/3 participants had normal Meibography and 92.4% had conjunctival redness in the normal range.

The study shows weak to moderate correlations between the effects of exposure to different light-related variables and measures of the ocular surface. Results of the total minutes spent under natural light revealed that young adults in the Qassim region spent an average of 30.90 ± 24.30 minutes in natural light during the daytime. They are exposed to blue light at night for 17.60 ± 19.70 minutes.

We have discovered a potential link between midnight blue light exposure and the onset or worsening of dry eye symptoms. The results showed a significant correlation between exposure to blue light at night and tear TMH (Table 1). Our findings underline the importance of proper screen habits and blue light management to maintain ocular health. There was a negative connection between TMH and the blue light component at night, showing that nighttime exposure to higher levels of blue light may be linked to less stable tear films.

Table 1: *Correlation between light exposure duration with TMH and NIKBUT.*

Parameter	Right eye		Left eye	
	TMH	NIKBUT	TMH	NIKBUT
Natural light	-0.294	-0.159	-0.260	0.120
Blue light	-0.622*	-0.308	-0.446*	0.017

*Significant correlation; TMH: Tear meniscus height; NIKBUT: Non-invasive Keratograph breakup time.

In the current study, distinct patterns of association emerged during daytime and nighttime conditions (Table 2). During daylight hours, Kelvin showed a statistically significant inverse connection with TMH ($r=-0.531$, $p<0.05$) and NIKBUT ($r=-0.573$, $p<0.05$). This implies an inverse relationship, suggesting that as Kelvin values augment, there is a concurrent reduction in both TMH and NIKBUT values and vice versa. However, under nocturnal conditions, although Kelvin retained a negative correlation with both measures, it only reached statistical significance with NIKBUT ($r=0.718$, $p<0.05$).

Table 2: *Light parameters correlation with ocular surface parameters.*

Parameter	Day		Night	
	TMH	NIKBUT	TMH	NIKBUT
Kelvin	-0.531*	-0.573*	-0.360	-0.718*
Red	-0.467	-0.536*	-0.111	-0.155
Green	-0.416	-0.500	-0.060	-0.173
Blue	-0.485	-0.509	-0.097	-0.236
Infrared	-0.475	-0.410	0.120	-0.064
mEDI	-0.536*	-0.555*	-0.388	-0.600*

*Significant correlation; TMH: Tear meniscus height; NIKBUT: Non-invasive Keratograph breakup time.

We observed a substantial inverse and statistically significant association between mEDI and TMH ($r=-0.536$, $p<0.05$) as well as NIKBUT ($r=-0.555$, $p<0.05$) during the day in our study. It is interesting to note that although the nocturnal link with NIKBUT continued to be statistically significant (r=-0.600, p<0.05), the association with TMH did not reach the significance level, even though it was still negative. The red component (R) demonstrated a negative correlation with TMH and NIKBUT during both day and night, but the relationship reached statistical significance only with NIKBUT in daylight (r=-0.536, p<0.05). The green (G) and blue (B) components consistently showed negative associations with TMH and NIKBUT across both periods, although none of these correlations were statistically significant. However, the tendency of blue light to cause a reduction in NIKBUT indicates a potential link between increased blue light exposure at night and decreased tear stability. However, it is also important to remember that correlation does not infer causation. No significant correlations were observed with other dry eye symptoms, such as Schirmer test results or meibography.

DISCUSSION

Several light characteristics were shown to be related to dry eye symptoms in the current research. Study of ocular surface and light exposure shows a range of weak to substantial correlations between the exposure to different light-related variables and the ocular surface. For instance, the correlation between increased duration of blue light exposure at night and lower NIBUT was weak, as evidenced by a Pearson correlation coefficient (r) of 0.3. However, a notable negative correlation was observed between the blue component of light exposure at night and the noninvasive tear Breakup Time (NIBUT), with an R-value of 0.7. This indicates a potential link between increased blue light exposure at night and decreased tear stability, but it is also important to remember that correlation does not infer causation. No significant correlations were observed with other dry eye parameter, such as Schirmer test results or Meibography.

A significant negative correlation was detected between Kelvin and Blue Light (-.572) and NIKBUT(-.447). This suggests that an increase in Kelvin values is associated with a decrease in Blue Light and NIKBUT values. These findings offer valuable insight into the relationship between light exposure and ocular health.

We also measured Melanopic Equivalent Daylight Illuminance (mEDI) or melanopic lux, which refers to a measurement of light intensity that is weighted for the response of melanopsin.[18] Melanopsin is a light-sensitive pigment found in intrinsically photosensitive retinal ganglion cells (ipRGCs) in the eye. It is recognized for producing visual signals independent of the conventional rods and cones photoreceptors.[19] It is crucial in controlling many light-adaptive processes, including pupil reaction to light, photoentrainment of the circadian cycle, mental state, and sleep. In addition to these roles, melanopsin has been recently identified in non-retinal tissues.[20,21] Although the exact function of melanopsin in these tissues remains to be clarified, its presence indicates that it may contribute to various sensory or regulatory functions beyond light perception.[21]

We have discovered a potential link between midnight blue light exposure and the onset or worsening of dry eye symptoms. Our study aligns with Zhao et al, findings, demonstrating the potential harm of blue light on ocular health, including contributing to dry eye symptoms. Remarkably, both studies indicate that exposure to blue light, particularly at night, may impair tear film integrity and exacerbate symptoms of dry eyes.[22] These findings highlight a need for further research into the systemic effects of blue light exposure and preventive strategies to mitigate its potential harm.

Our study aligns with the findings of Tosini et AL, which shows impact of blue light exposure from LEDs on ocular health. We found that blue light, particularly at nighttime, can have a detrimental impact on ocular surface and can lead to symptoms of dry eyes.[23] Our study also supports prior findings by Al-Mohtaseb et al, that prolonged digital screen exposure, especially at night, contributes to dry eye disease.[24] The research furthered this understanding by establishing a correlation between daily exposure to blue light emitted from digital screens and heightened symptoms of dry eye syndrome. Thus, highlighting the importance of proper screen habits and blue light management to maintain ocular health. There was a negative connection between NIBUT and the blue light component at night, suggesting that nighttime exposure to higher levels of blue light may be linked to less stable tear films.

The current study revealed different patterns of association between Kelvin and critical parameters of dry eye disease – TMH and NIKBUT - in the daytime and nighttime conditions. During the day, a significant inverse relationship was found between Kelvin and both TMH and NIKBUT. This suggests that as Kelvin values increase, both TMH and NIKBUT values decrease and vice versa. However, in the nighttime conditions, although Kelvin still showed a negative correlation with both measures, it was not statistically significant.

In spite of the observed correlations, no definitive causal link was established between exposure to blue light and the initiation of dry eye symptoms. This means that additional research is required to fully comprehend the mechanisms underlying these associations, establish causality, and ascertain whether reducing exposure to blue light could effectively lower the risk or severity of dry eye symptoms. However, these findings offer valuable insights that may help shape future studies and preventive strategies targeting dry eye disease.

While the study provides valuable insights into the correlation between light exposure and dry eye symptoms, several limitations should be considered. These include cross-sectional design, small sample size, sample from a single institution resulting in lack of generalize ability and participants wearing light sensor buttons for only one week, which may not capture long-term patterns of light exposure. Addressing these limitations in future research, such as using longitudinal designs, increasing sample sizes, accounting for confounding variables, and diversifying participant populations, would strengthen the validity and applicability of the findings.

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Patient's Consent: Researchers followed the guidelines set forth in the Declaration of Helsinki.

Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board **(21-20-09)**.

REFERENCES

1. **Gomes JAP, Azar DT, Baudouin C, Bitton E, Chen W, Hafezi F, et al.** TFOS Lifestyle: Impact of elective medications and procedures on the ocular surface. Ocul Surf. 2023;**29:**331-385. Doi: 10.1016/j.jtos.2023.04.011.
2. **Perez VL, Mousa HM, Soifer M, Beatty C, Sarantopoulos S, Saban DR, et al.** Meibomian Gland Dysfunction: A Route of Ocular Graft-Versus-Host Disease Progression That Drives a Vicious Cycle of Ocular Surface Inflammatory Damage. Am J Ophthalmol. 2023;247. Doi: 10.1016/j.ajo.2022.09.009.
3. **Rico-Del-Viejo L, Benítez-Del-Castillo JM, Gómez-Sanz FJ, García-Montero M, Llorens-Quintana C, Madrid-Costa D.** The influence of meibomian gland loss on ocular surface clinical parameters. Cont Lens Anterior Eye. 2019;**42(5):**562-568. Doi: 10.1016/j.clae.2019.04.004.
4. **Alfaro-Juárez A, Caro-Magdaleno M, Montero-Iruzubieta J, Fernández-Palacín A, Muñoz-Morales A, Castilla-Martino MA, et al.** Keratograph 5M As a Useful and Objective Tool for Evaluating the Ocular Surface in Limbal Stem Cell Deficiency. Clin Ophthalmol. 2019;**13:**2025-2033. Doi: 10.2147/OPTH.S218313.
5. **Okumura Y, Inomata T, Iwata N, Sung J, Fujimoto K, Fujio K, et al.** A Review of Dry Eye Questionnaires: Measuring Patient-Reported Outcomes and Health-Related Quality of Life. Diagnostics (Basel). 2020;**10(8):**559. Doi: 10.3390/diagnostics10080559.
6. **Tian L, Qu JH, Zhang XY, Sun XG.** Repeatability and Reproducibility of Noninvasive Keratograph 5M Measurements in Patients with Dry Eye Disease. J Ophthalmol. 2016;**2016:**8013621. Doi: 10.1155/2016/8013621.
7. **Panagiotou M, Deboer T.** Effects of chronic dim-light-at-night exposure on sleep in young and aged mice. Neuroscience. 2020;**426:**154-167.
8. **Panda S, Sato TK, Castrucci AM, Rollag MD, DeGrip WJ, Hogenesch JB, et al.** Melanopsin (Opn4) requirement for normal light-induced circadian phase shifting. Science. 2002;**298(5601):**2213-2216. Doi: 10.1126/science.1076848.
9. **Spitschan M, Santhi N.** Individual differences and diversity in human physiological responses to light. E Bio Med. 2022;**75:**103640. Doi: 10.1016/j.ebiom.2021.103640.
10. **Suh YW, Na KH, Ahn SE, Oh J.** Effect of Ambient Light Exposure on Ocular Fatigue during Sleep. J Korean Med Sci. 2018;**33(38):**e248. Doi: 10.3346/jkms.2018.33.e248.

11. **Naeem Z, Al-Mohaimeed A, Sharaf FK, Ismail H, Shaukat F, Inam SB.** Vitamin D status among population of Qassim Region, Saudi Arabia. Int J Health Sci (Qassim). 2011;**5(2):**116-124. PMID: 23267289;
12. **Alghamdi AS, Alghamdi KA, Jenkins RO, Alghamdi MN, Haris PI.** Impact of Ramadan on Physical Activity and Sleeping Patterns in Individuals with Type2 Diabetes: The First Study Using Fitbit Device. Diabetes Ther. 2020;**11(6):**1331-1346. Doi: 10.1007/s13300-020-00825-x.
13. **Alharbi M, Bauman A, Alabdulaali M, Neubeck L, Smith S, Naismith S, et al**. Comparison of Different Physical Activity Measures in a Cardiac Rehabilitation Program: A Prospective Study. Sensors (Basel). 2022;**22(4):**1639. Doi: 10.3390/s22041639.
14. **Joyce DS, Zele AJ, Feigl B, Adhikari P.** The accuracy of artificial and natural light measurements by actigraphs. J Sleep Res. 2020;**29(5):**e12963. Doi: 10.1111/jsr.12963.
15. **Bakkar MM, El-Sharif AK, Al-Qadire M.** Validation of the Arabic version of the Ocular Surface Disease Index Questionnaire. Int J Ophthalmol. 2021;**14(10):**1595-1601. Doi: 10.18240/ijo.2021.10.18.
16. **Jones LW, Rahman S, Leech R, Simpson T, Fonn D.** Determination of inferior tear meniscus height and inferior tear meniscus volume using optical coherence tomography. Invest Ophthalmol Vis Sci. 2004;**45(13):**144-.
17. **Chidi-Egboka NC, Briggs NE, Jalbert I, Golebiowski B.** The ocular surface in children: A review of current knowledge and meta-analysis of tear film stability and tear secretion in children. Ocul Surf. 2019;**17(1):**28-39. Doi: 10.1016/j.jtos.2018.09.006.
18. **Trinh VQ, Bodrogi P, Khanh TQ.** Determination and Measurement of Melanopic Equivalent Daylight (D65) Illuminance (*mEDI*) in the Context of Smart and Integrative Lighting. Sensors (Basel). 2023;**23(11):**5000. Doi: 10.3390/s23115000.
19. **Alkozi HA, Wang X, Perez de Lara MJ, Pintor J.** Presence of melanopsin in human crystalline lens epithelial cells and its role in melatonin synthesis. Exp Eye Res. 2017;**154:**168-176. Doi: 10.1016/j.exer.2016.11.019.
20. **Mure LS.** Intrinsically Photosensitive Retinal Ganglion Cells of the Human Retina. Front Neurol. 2021;**12:**636330. Doi: 10.3389/fneur.2021.636330.
21. **Trier AM, Mack MR, Kim BS.** The Neuroimmune Axis in Skin Sensation, Inflammation, and Immunity. J Immunol. 2019;**202(10):**2829-2835. Doi: 10.4049/jimmunol.1801473.
22. **Zhao ZC, Zhou Y, Tan G, Li J.** Research progress about the effect and prevention of blue light on eyes. Int J Ophthalmol. 2018;**11(12):**1999-2003. Doi: 10.18240/ijo.2018.12.20.
23. **Tosini G, Ferguson I, Tsubota K.** Effects of blue light on the circadian system and eye physiology. Mol Vis. 2016;**22:**61-72.
24. **Al-Mohtaseb Z, Schachter S, Shen Lee B, Garlich J, Trattler W.** The Relationship Between Dry Eye Disease and Digital Screen Use. Clin Ophthalmol. 2021;**15:**3811-3820. Doi: 10.2147/OPTH.S321591.

Author's Designation and Contribution

Hanan Awad Alkozi; Assistant Professor: *Concepts, Design, Literature search, Data acquisition, Data analysis, Statistical analysis, Manuscript preparation, Manuscript editing Manuscript review.*

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