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Original Article

Awareness, protective practices, and the association of LED screen use with premature aging in adults: A cross-sectional study

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Abstract

Background High-energy visible (HEV) blue light from LED screens may contribute to premature skin aging by causing oxidative stress and collagen breakdown, especially with prolonged exposure.

Objective To assess awareness and protective practices regarding LED screen-related skin aging and to determine the association between LED screen exposure and self-reported premature aging indicators among adults.

Methods In PNS Shifa Hospital, Karachi, a cross-section study was conducted from October 2023 to May 2024 after getting ethical approval. The age range of 450 participants was 27-40, who were enrolled in the study. A structured online self-administered questionnaire developed using Google Forms and distributed electronically was used to collect data on demographics, LED screen exposure, sunscreen use, and antioxidant products such as vitamin C serums and antioxidant creams. Statistical analysis was conducted using the SPSS version 29.

Results Among 450 participants, prolonged LED screen exposure was associated with self-reported signs suggestive of premature skin aging, including fine wrinkles, pigmentation, dark circles, and hair-related changes. A considerable proportion of participants were aware of the potential harmful effects of LED exposure; however, the adoption of preventive practices such as sunscreen use and antioxidant products was limited. Significant associations were observed between increased screen time and reported aging-related skin changes.

Conclusion Adherence to protective measures remains insufficient even though awareness is at a moderate level. One of the major factors contributing to premature aging is long-term exposure to LED screens, which calls for better public education and digital photoprotection measures.

Keywords Light-Emitting diodes; Skin aging; Sunscreening agents; Health knowledge; Screen time.

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Introduction

Premature skin aging refers to the early appearance of wrinkles, pigmentation changes, and loss of skin elasticity due to intrinsic and extrinsic factors, including visible light exposure. Traditionally, ultraviolet (UV) radiation from solar exposure has been recognized as the primary environmental contributor to photoaging, exerting its effects

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through the generation of reactive oxygen species (ROS) that induce oxidative stress and direct DNA damage.[1] However, with the widespread adoption of digital technologies in modern lifestyles, emerging evidence suggests that exposure to high-energy visible (HEV) light particularly blue light emitted from light-emitting diode (LED) screens-may also play a contributory role in the pathogenesis of premature skin aging.[1,2]

At the wavelength of around 400 to 500 nanometers, we are exposed to blue light (which is emitted by all electronic devices) more often than to the sun. UV has enough energy to cause an effect, however, blue light can penetrate the skin's dermal connective tissues, thus producing ROS which may then cause more oxidative stress.[3] This has been confirmed once again in 2023 by the Journal of Cosmetic Dermatology which reported that skin hyperpigmentation induced by blue light potentially causes premature skin aging and also facilitates its pathogenesis. Nitric oxide and ROS are the causes of such events, as explained in the article.[3,4]

Although research on the association between blue light exposure and skin aging is still emerging, a number of different pathways have been suggested by the evidence for the quicker aging process due to exposure to blue light.[5] Conceptually and scientifically, the side effects of blue light exposure include reduced collagen production, extracellular matrix degradation, and increased oxidative stress in fibroblasts, all of which contribute to skin aging.[5] Additionally, such side effects involve disruption of the body's natural rhythms which is a situation that skin's repair mechanism becomes unable and thus, there is a worsening of the symptoms related to aging.[5,6]

With the increasing use of digital devices across all age groups, particularly among working and older adults, the concept of digital aging has gained growing attention. Digital aging refers to the cumulative effects of prolonged exposure of human skin to light emitted from electronic screens over time.[7,8]

While public awareness regarding the impact of blue light on the skin and the processes of its aging has been growing, particularly in the fields of dermatology and cosmetology, studies indicate a significant gap between awareness and practice.[8,9] This is particularly relevant among individuals who are unaware of proper skin care practices or do not realize that even limited exposure may contribute to skin damage. Furthermore, as there are no public education campaigns about blue light protection, in contrast to the UV protection, the divide will become even greater. A person, for example, may apply sunscreen to shield their skin from UV rays but disregard the necessity of using a sunscreen which protects against visible and blue light as well and of altering their lifestyle to include less exposure to the electronic screens and antioxidants.[9,10]

Protecting the skin from blue light includes a strategy of applying sunscreen that filters the entire spectrum of radiation and contains iron oxides that can block visible light along with the use of topical antioxidants (such as vitamins C and E, and niacinamide) to neutralize reactive oxygen species and boost skin's endurance.[8-10] Also, changing one's habits to minimize the output of blue light from digital gadgets by means of night mode or blue light filtering features has been widely promoted by experts and the medical community.

Previous studies have shown that visible and blue light exposure may adversely affect skin health through oxidative stress, pigmentation changes, and extracellular matrix degradation. Liebel *et al*. reported increased reactive oxygen species and matrix-degrading enzymes following visible light exposure, while Duteil *et al*. and Kim *et al*. demonstrated pigmentation and clinical skin changes associated with repeated exposure.[5-7] Christensen *et al*. and Zhang *et al*. further highlighted the need for protective strategies against blue light–induced skin aging.[8,9] In Pakistan, Amin *et al*. found limited sunscreen use practices, emphasizing the need for

greater awareness regarding photoprotection.[10] However, there is limited practical evidence regarding the effectiveness of these protective measures, and the potential associations between awareness and preventive practices on one side and signs of accelerated skin aging such as wrinkles, hyperpigmentation, and reduced skin elasticity on the other have not been well demonstrated in population studies.[8-10]

It is this gap in knowledge that points out the necessity for research being community-first. The effects of LED exposure, as well as aging, should be studied not only in terms of exposure and aging outcome but also from the perspective of public general awareness and the level of protective practices implementation.

Methods

This descriptive observational study was designed as a cross-sectional survey and took place in PNS Shifa Hospital, Karachi, Pakistan, over a period from October 2023 to May 2024. The study was carried out after approval by the Institutional Ethics Review Committee (ERC/2023/DERM/45 dated 05.10.2023). 450 adults of age ranging 27-40 years were recruited through a convenience sampling technique from among hospital visitors, such as patients, hospital staff, and attendants. The sample size was determined using OpenEpi software based on prevalence estimates from existing studies to ensure the study was statistically powerful.[11] This age group was selected because early clinical signs of premature skin aging are more likely to become apparent during these years, while cumulative exposure to LED screens is substantial.

Participants aged 27-40 years of either gender, with regular exposure to LED-emitting screens/ devices and willing to provide informed verbal consent, were included in the study. To minimize the influence of confounding factors on skin aging, certain restrictions were applied. The exclusion criteria included polycystic ovary syndrome, thyroid disorders, and active dermatological diseases (e.g., melasma, dermatitis, or erythema), as well as pregnancy, lactation, and a history of cosmetic or dermatological procedures. Active dermatological diseases such as melasma were excluded due to their independent effects on skin pigmentation, while individuals with PCOS were excluded because hormonal disturbances may independently alter skin texture and appearance. Information was obtained through a structured, self-administered survey that was made available online. The survey covered questions regarding demographic traits of participants, LED screen exposure habits (including the device type and average daily screen time), knowledge about LED-induced premature aging, employing preventive tactics such as SPF sunscreen, antioxidants, and anti-aging serums, and finally, self-reported symptoms of premature aging like fine wrinkles, skin dryness, hyperpigmentation, hair graying, hair loss, and loss of skin firmness. Participants were recruited through convenience sampling from hospital visitors, staff, and attendants at PNS Shifa Hospital. Eligible participants were approached in person at PNS Shifa Hospital and, after providing informed consent, were invited to complete an electronic questionnaire using Google Forms. After eligibility assessment and informed consent, participants completed the questionnaire electronically using Google Forms, either on their personal devices or with assistance when required. The use of an electronic questionnaire was intended to facilitate standardized data collection and minimize data-entry errors.

The data were analyzed using SPSS version 29. Descriptive statistics were done, and the relationship between LED screen exposure and the signs of premature aging was tested by chi-square, a *P*-value <.05 was considered statistically significant.

Result

The demographic attributes of the target community are shown in **Table 1**, which has revealed a balance in gender and a distribution of the population within the specified age groups and occupations.

Table 1 Demographic characteristics of participants.

Variable	*Frequency (n)*	*Percentage (%)*
Age (years)		
27-30	100	22.2%
31-35	250	55.6%
36-40	100	22.2%
Gender		
Male	225	50%
Female	225	50%
Occupation		
Doctor	100	22.2%
Officer	100	22.2%
Teacher	100	22.2%
Banker	50	11.1%
Housewife	50	11.1%
Other	50	11.1%

Table 2 Awareness and protective measures (n=450).

Variable	*Frequency (n)*	*Percentage (%)*
Awareness of LED-induced premature aging		
Yes	300	66.7%
No	150	33.3%
Use of SPF Sunblock		
Yes	150	33.3%
No	300	66.7%
Frequency of SPF Re-application		
1-2 hours	50	11.1%
3-4 hours	100	22.2%
5-6 hours	150	33.3%
>6 hours	50	11.1%
Do Not Reapply	50	11.1%
Use of antioxidants/antiaging serums		
Yes	175	38.9%
No	275	61.1%

Table 3 Association between LED usage and premature aging indicators (n=450).

Premature Aging Indicator	*Present n (%)*	*Absent n (%)*	*P-value*
Fine wrinkles on face	300 (66.7)	150 (33.3)	<.01
Dry skin	250 (55.6)	200 (44.4)	<.01
Graying of hair	200 (44.4)	250 (55.6)	<.05
Hair fall	275 (61.1)	175 (38.9)	<.01
Dark circles / discoloration spots	325 (72.2)	125 (27.8)	<.01
Decreased skin elasticity / open pores	250 (55.6)	200 (44.4)	<.01

The level of awareness about LED-induced premature aging and the practice of preventive measures are listed in **Table 2**. While the majority of participants showed awareness about the aging effects of LED exposure, the overall practice of preventive measures was not satisfactory. The use of SPF sunscreen and antioxidant or anti-aging products was low, and irregular reapplication of sunscreen was noted among the users.The relationship between LED screen exposure and the self-reported symptoms of premature aging is described in **Table 3**. The overall exposure to LED screens had statistically significant relationships with various clinical manifestations of premature aging, such as fine wrinkles on the face, skin dryness, hyperpigmentation, hair loss, dark circles or discoloration, and loss of skin elasticity. Hair graying was also found to have a statistically significant relationship with increased exposure to screens. In general, increased exposure to LED screens on a daily basis was found to be associated with increased symptoms of premature aging.

Discussion

The study results revealed a statistical association between longer LED screen exposure and participants' self-reported perception of early aging-related changes, including fine wrinkles, skin dryness, hyperpigmentation, hair loss, hair graying, and reduced skin elasticity. The study findings are consistent with recent dermatological research suggesting that digital screens emit high-energy visible (HEV) blue light radiation, which has been shown to induce oxidative stress in skin cells, which in turn causes the appearance of aging signs.[12]

The research showed that about 66% of the respondents were aware of the potential risk of LED screen exposure in premature skin aging; however, this awareness did not translate into effective protective practices to protect themselves from this risk. Only about 33% of the participants in the study reported that they regularly used SPF sunscreen, while the use of antioxidants and anti-aging creams was below 40%. Several community-level research studies in dermatology have indicated that knowledge of treatment options is not sufficient to motivate people to adopt preventive measures.[11,12]

Previous experimental studies have demonstrated through in vitro and in vivo models that exposure to visible light elevates matrix metalloproteinase activity, which demonstrated that matrix metalloproteinases were elevated after the participants were subjected to visible light.[15,16]

This study demonstrates a strong association between LED screen exposure and hyperpigmentation which is consistent with earlier studies that reported that visible light stimulates melanocyte activity especially in people with darker skin tones.[17,18] The skin pigmentation induced by blue light involves two biological mechanisms that comprise nitric oxide production and oxidative stress, which ultimately lead to skin color irregularities and loss of normal skin tone.[18,19]

The link between prolonged screen time and hair changes, such as hair loss and greying, has not been extensively studied; however, oxidative stress associated with prolonged screen exposure may influence melanocytes and keratinocytes of the hair follicle, although other contributing factors may also play a role. A recent study suggests that environmental oxidative damage may be one of the reasons for follicular aging and loss of melanocytes, which in turn, may cause hair graying at an early age in genetically susceptible individuals.[18,19]

Protective strategies, such as the use of broad-spectrum sunscreens containing iron oxide pigments and topical antioxidant agents, have been demonstrated to reverse visible light-induced oxidative injury.[19-20] Nevertheless, the present study revealed that participants were not uniform in the regular reapplication of sunscreen, and the overall use of antioxidants was generally poor. Dermatologists should emphasize the importance of photoprotection not only against ultraviolet radiation but also against visible and blue light exposure.

Some limitations in the study should be recognized. A restriction of the cross-sectional study is that it cannot determine the cause-effect relationship between LED screen exposure and premature aging outcomes. Information leaflets on exposure to screens, protective measures, and signs of aging were of self-report type and, therefore, the study may suffer from recall and reporting bias. Residual confounding from unmeasured factors such as cumulative daily sun exposure, genetic predisposition, nutritional status, sleep quality, and other environmental or lifestyle factors cannot be excluded and may have influenced the observed associations. The use of a single-center convenience sample constitutes a factor limiting the generalizability of the findings to the broader population. As the dermatological manifestations assessed in this study were based on self-reported perceptions rather than objective clinical examination, reporting bias and inter-individual variation in symptom recognition may have influenced the findings.

Further research with a longitudinal design and objective clinical as well as biochemical markers of oxidative stress is required to disclose the mechanisms in detail.

Conclusion

Prolonged LED screen exposure was associated with self-reported signs suggestive of premature aging of the skin. Although the participants had a moderate level of knowledge, preventive measures were inadequate. In order to protect our skin from the harmful effects of the constantly increasing exposure to screens, it is necessary to initiate training programs and make digital photoprotection part of dermatology practice.

Declaration of patient consent Authors certify that they have obtained all appropriate patient consent.

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Author's contribution

SK: Substantial contribution acquisition of data and critical review of the manuscript.

SBA,AB: Substantial contribution analysis, interpretation of data, drafting the manuscript.

SA: Substantial contribution acquisition of data and critically review the manuscript.

MA: Substantial contribution analysis, interpretation of data and review the manuscript.

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