RESEARCH ARTICLE

Association of light emitting diodes (LED) devices with premature ageing: A cross-sectional descriptive study

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Abstract

Objective: To assess the relationship between light-emitting diode device usage and premature ageing.

Method: The cross-sectional, descriptive study was conducted from October 2023 to May 2024 after approval from the ethics review committee of Pakistan Naval Ship Shifa Hospital, Karachi, and comprised individuals aged 27-40 years. Other than demographic characteristics, data was collected about light-emitting diode device usage and indicators of premature ageing based on self-reported and observed features. Data was analysed using SPSS 29.

Results: Of the 450 participants with mean age 32.4±3.7 years, 225(50%) each were males and females. Commonly used devices were mobile phones 400(88.9%), television 350(77.8%) and laptops 300(66.7%). Overall, 200(44.4%) subjects reported 5-7 hours of screen time, and 300(66.7%) did not use ultraviolet protection. Devices were used at a distance of 10-20cm by 200(44.4%) subjects. In terms of premature ageing signs, the most common was dark circles 325(72.2%), while greying of hair was the least common 200(44.4%). All ageing variables showed a highly significant association with light-emitting diode usage ($p<0.01$), with the exception of greying of hair which demonstrated a significant association but at a lower level ($p<0.05$).

Conclusion: There was a significant link between light-emitting diode device usage and premature ageing.

Keywords: Light-emitting diode, Premature ageing, Screen time. (JPMA 76: 176; 2026)

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Introduction

Light-emitting diode (LED) devices have shown a marked increase with the advancements in latest technologies. They are now used in computer, tablet, smartphone and television (TV) screens, and have advanced into medical hospital setups as well.[1] According to research in Saudi Arabia, >98% of medical students own a smartphone, and nine out of 10 use their smartphones at bedtime.[2] Usually at night, smartphones and other electronics with LED screens are the most frequent emitters of blue light. From a distance of 10cm, using a smartphone that produces a 453nm blue light can reduce the quality of sleep.[3] Extensive use of electronic devices and increased exposure to artificial blue light — also known as high-energy visible (HEV) light — can exert cytotoxic effects associated with oxidative stress, and promote hyperpigmentation.[4] LED screens in digital devices, such as smartphones, laptops, tablets and TVs, primarily emit visible light in the blue spectrum, typically ranging between 400 and 490 nanometres (nm). This segment of the spectrum, often referred to as HEV light, is known to penetrate deeper into the skin than ultraviolet-B (UVB) radiation, and has been implicated in oxidative stress, melanin synthesis, and skin ageing processes.[5] Recent studies show that light emitted from electronic devices may cause reactive oxygen species (ROS) generation, apoptosis, and necrosis of human skin cells even if exposed for a duration as low as 1 hour.[5] There is loss of circadian rhythm due to melatonin dysregulation, leading to insomnia and sleep disturbances.[6] These rays target the mitochondria, which serve as initiators of inflammation, due to damage to endogenous nucleic acids, involvement of aromatic amino acids, urocanic acid, tryptophan, tyrosine, nicotinamide adenine dinucleotide phosphate (NADPH), nicotinamide adenine dinucleotide-hydrogen (NADH) cofactors, cytochromes, riboflavin, porphyrins, protoporphyrin IX, bilirubin, haemoglobin and carotene.[7] This leads to induced cytotoxicity, and decrease in cell viability.[8] Immediate biological effects may manifest as erythema or sunburn, and may convert to neoplasms or premature ageing upon long-term exposure. A study in Germany revealed that the concentration of matrix metalloproteinase-1 (MMP-1) increases after irradiation with blue light, while the concentration of type 1 procollagen decreases, which could cause premature ageing[9] Premature ageing may occur as a result of telomere shortening, programmed senescence, genomic instability, and loss of heterochromatin architecture.[10] UVB and UVA are primarily responsible for the photo-aged appearance of skin, including the five key signs of skin

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ageing: fine lines and wrinkles, enlarged pores, redness, pigmentation, and sagging skin.[11] A study provided preliminary evidence that LEDs cause down-regulation of aquaporin 1 (AQP1), 3 and 9 which could also be a possible mechanism of premature ageing.[12] It has also been concluded in research that artificial visible light induces normal human fibroblasts to undergo drastic molecular and cellular changes. This may interfere with normal cellular functions and contribute to premature skin ageing.[13] However, none of these studies have measured the association of LEDs with premature ageing amongst humans.

The current study was planned to assess the association of LED devices with premature ageing in individuals, and to explore the factors contributing to the process.

Subjects and Methods

The cross-sectional, descriptive study was conducted from October 2023 to May 2024 after approval from the ethics review committee of Pakistan Naval Ship (PNS) Shifa Hospital, Karachi, and comprised individuals aged 27-40 years. The sample size was calculated using Open Epi version 3.01 while assuming an anticipated frequency of 50%[14] to ensure maximum variability, 95% confidence level, 5% margin of error, and design effect 1.0. To strengthen statistical power and allow subgroup analysis, the sample was inflated by >15%. The sample was raised using convenience sampling technique from among those visiting the hospital, including faculty, staff, attendants and patients. Individuals with chronic illnesses, such as diabetes, thyroid disorders, liver or kidney disease, or autoimmune conditions were excluded. Individuals with genetic or dermatological conditions linked to premature ageing, such as progeroid syndromes, xeroderma pigmentosum, or albinism, were also not excluded, and so were those with photosensitisation disorders, recent cosmetic procedures, or chronic skin diseases, like melasma or dermatitis. Finally, pregnant or breastfeeding women and those on hormonal therapy were also excluded to minimise confounding factors.

After taking written informed consent from the participant, data was collected using an online questionnaire that was three sections. The initial segment encompassed essential demographic characteristics, including age range and professional designation. The second section focussed on LED usage, examining factors such as average screen time, UV protection settings, proximity to the skin, and duration of exposure. The final portion addressed indicators of premature ageing. Premature ageing signs were assessed based on self-reported and observed features, including periorbital hyperpigmentation (commonly referred to as dark circles), and facial hyperpigmented macules or lentigines (generally referred to as discolouration spots). These were typically located on sun-exposed facial areas, such as the cheeks, forehead and upper lip. Other factors included greying of hair, and decreased skin elasticity characterised by sagging or wrinkling. Open pores were not assessed as an ageing marker.

Data was analysed using SPSS 29. Descriptive statistics were used, including frequencies and percentages for categorical variables and means ± standard deviation for continuous variables. Inferential statistics were applied using the chi-square test to assess the association involving screen time, LED device usage characteristics, and various premature ageing indicators. P<0.05 was considered statistically significant, while $p<0.01$ was considered highly significant.

Results

Of the 500 individuals approached, 450(90%) completed the questionnaire; 225(50%) each being males and females. The overall mean age was 32.4±3.7 years. Most respondents had a professional background 350(77.8%) (Table 1).

Commonly used devices were mobile phones 400(88.9%), television 350(77.8%) and laptops 300(66.7%). Overall, 200(44.4%) subjects reported 5.3±1.8 hours (range: 5-7 hours) of daily screen time, and 300(66.7%) did not use UV protection. Devices were used at a distance of 10-20cm by 200(44.4%) subjects (Table 2).

In terms of premature ageing signs, the most common was dark circles 325(72.2%), while greying of hair was the least common 200(44.4%) (Table 3).

All ageing variables showed a highly significant association with LED usage ($p<0.01$), with the exception of greying of hair which demonstrated a significant association, but at a

Table-1: Demographic characteristics.

Variable	n (%)
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: Data about LED device usage.

Variable	n (%)
Types of LED Devices Used	
Mobiles	400 (88.9)
Laptops	300 (66.7)
Computers	250 (55.6)
Tablets	150 (33.3)
Television	350 (77.8)
Average Screen Time	
<2 hours	50 (11.1)
2-4 hours	150 (33.3)
5-7 hours	200 (44.4)
>7 hours	50 (11.1)
Use of UV Protection Filter/Night Mode	
No	300 (66.7)
Yes	150 (33.3)
Screen Proximity	
10-20 cm	200 (44.4)
21-30 cm	150 (33.3)
31-40 cm	75 (16.7)
41-50 cm	25 (5.6)
Duration of Regular Use	
<1 year	50 (11.1)
1-2 years	100 (22.2)
2-5 years	200 (44.4)
>5 years	100 (22.2)

LED: Light-emitting diode, UV: Ultraviolet.

Table-3: Premature aging indicators.

Variable	n (%)
Fine Wrinkles on Face	
Yes	300 (66.7)
No	150 (33.3)
Dry Skin	
Yes	250 (55.6)
No	200 (44.4)
Greying of Hair	
Yes	200 (44.4)
No	250 (55.6)
Hair Fall	
Yes	275 (61.1)
No	175 (38.9)
Dark Circles/Discoloration Spots	
Yes	325 (72.2)
No	125 (27.8))
Decreased Skin Elasticity/ (Sagging/Wrinkling)	
Yes	250 (55.6)
No	200 (44.4)

Table-4: Association between screen time and premature aging indicators.

Screen Time (hours)	Mean Age (years)	Fine Wrinkles (%)	Dry Skin (%)	Greying of Hair (%)	Hair Fall (%)	Dark Circles (%)	Decreased Skin Elasticity (sagging/wrinkling) (%)	*p*-value
<2	32	10	8	5	12	15	8	<0.05
2-4	33	20	18	15	22	25	18	<0.01
5-7	34	35	30	25	35	40	30	<0.01
>7	35	45	40	35	45	50	40	<0.01

Discussion

The current study found a notable association between prolonged screen time and premature ageing, with many participants lacking UV protection and using devices at close distances. A positive correlation was observed between screen time and premature ageing indicators, with longer screen times showing a stronger association with signs like dark circles and discolouration spots. UV radiation from LED devices can cause skin damage, including photo-ageing, erythema, and the generation of ROS. Visible light from these devices also contributes to ROS production, pigmentation, and the formation of fine wrinkles. This explains issues such as skin discolouration and pigmentation.[15] The majority of participants used mobile phones (88.9%), followed by TVs (77.8%) and laptops (66.7%). This trend mirrors a similar study conducted in China.[16] Notably, the average screen time in the Chinese population was significantly lower, averageing 1-3 hours daily, compared to 7-8 hours reported in.[16] A 2024 study found that only 10% of individuals used blue light filters regularly, another 10% used them occasionally, and 80% never used them.[17] This aligns with the current findings. Additionally, the earlier study highlighted a significant positive correlation between blue light filter use and sleep problems in the majority of the population.[17]

Although the molecular and cellular mechanisms behind hair greying are not fully understood, various theories have been proposed. A study found that artificial light significantly increased protein loss in hair, with UVB effects being 2-5 times more damageing than UVA plus visible light.[18] The current study corroborates these findings, demonstrating a significant association between LED usage and greying of hair. This suggests that exposure to artificial light, particularly from LED devices, may contribute to the acceleration of hair greying through mechanisms that involve increased protein loss and other damageing effects.[18]

It is of significance to note that LED devices affect other areas of health. A study in Pakistan showed increased incidence of presbyopia amongst individuals with higher

screen time and greater exposure to LED devices.[19] Although there could be multiple other components contributing to ocular changes, rays from electronic devices showed a crucial role. A 2018 study on undergraduates found that the majority of students experienced vision problems (57.5%), followed by hearing issues (39%) and reduced physical activity (20%). Additionally, recent research suggests that increased screen time may be associated with a benign risk of autism spectrum disorders in children.[20,21] Based on these findings, it can be inferred that prolonged use of LED devices, particularly with inadequate protection, may contribute to accelerated skin ageing. This underscores the importance of educating the public about the potential risks associated with excessive screen time and the adoption of preventive measures, such as UV filters and skincare products containing antioxidants. Application of sunscreen before LED device usage can help reduce the premature ageing significantly. More awareness campaigns, advertisements and pamphlets would further underline the need of protection from harmful LED rays.

The current study's limitations include its cross-sectional design, which limits causal inference, and the reliance on self-reported data, which may have introduced bias in reporting screen time and skincare practices. A major limitation of the study is the absence of histopathological confirmation. While clinical features were used to assess premature ageing, no skin biopsies were performed to evaluate underlying changes in keratinocytes, melanocytes, collagen or elastin. Future studies incorporating histological and molecular analyses would be valuable to confirm the cellular and connective tissue alterations associated with chronic LED exposure.

While numerous studies have demonstrated the effects of blue light on fibroblasts and keratinocytes in vitro, there remains a paucity of human clinical data. Notably, a study involved irradiating the skin of eight healthy volunteers with visible blue light over five days, and skin biopsies showed no sunburn or inflammatory cell changes before or after exposure.[22] This suggests that short-term exposure may not yield acute histological effects. However, the current study explored associations over a longer duration of chronic use. Even then, future research involving long-term exposure protocols and molecular biomarkers, along with histological confirmation, is essential to better understand subtle photo-ageing mechanisms induced by LED light. Future research could explore longitudinal effects of LED device usage on skin ageing, incorporate objective measures of screen time and UV exposure, and assess the efficacy of different protective measures in mitigating premature ageing.

Conclusion

There was a significant association between prolonged LED device usage and premature ageing, with key factors being lack of UV protection and close screen distances. Increased screen time correlated with ageing indicators.

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Conflict of Interest: None.

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Author Contribution:
SR: Concept and supervision.
SMOS: Drafting.
YS: Data collection.
MRS: Statistical analysis.
SK: Literature review.
ZS: Data analysis and writing.