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The Relationship Between Blue Light Exposure from Digital Devices and the Acceleration of Premature Aging in Young Adults

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ABSTRACT

The use of digital devices among young adults has increased substantially, leading to higher exposure to blue light in everyday life. Blue light exposure has been associated with oxidative stress and cellular dysfunction of the skin, which are closely related to the aging process. This study aims to examine the relationship between blue light exposure from digital devices and accelerated premature aging among young adults. A quantitative explanatory approach with a cross-sectional design was employed using Structural Equation Modeling–Partial Least Squares (SEM–PLS). The sample consisted of 210 young adults aged 18–35 years who actively use digital devices. The results indicate that blue light exposure has a positive and significant effect on premature aging. These findings confirm that daily digital exposure represents a lifestyle-related risk factor contributing to accelerated skin aging. This study provides empirical evidence to support preventive strategies for skin health in the digital era.

Keywords: Blue light; Digital devices; Digital exposure; Premature aging; Young adults

INTRODUCTION

The rapid development of digital technology over the past two decades has fundamentally transformed patterns of daily activity, particularly among young adults. The use of digital devices such as smartphones, laptops, and tablets is no longer limited to work or educational purposes, but has become integrated into almost all aspects of life, including communication, entertainment, and personal activity management. The high intensity of digital device use positions young adults as the age group with the most dominant screen exposure compared to other age groups. This condition has generated growing health concerns, one of which relates to exposure to blue light emitted by digital devices.

Blue light is part of the visible light spectrum characterized by a short wavelength and high energy. A number of biological and clinical studies indicate that blue light exposure has the ability to penetrate deeper layers of the skin compared to certain types of ultraviolet radiation, thereby potentially affecting cellular skin functions. From a physiological perspective, blue light exposure has been associated with disruptions in circadian rhythms, increased oxidative stress,

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and alterations in cellular activity that play a role in skin aging processes. As the duration of digital device use continues to increase, concerns have emerged that chronic exposure to blue light may accelerate the onset of premature aging symptoms, even among individuals in their productive years.

This phenomenon has become increasingly relevant in light of reports indicating a rise in skin-related complaints among young adults, such as skin fatigue, dull appearance, early hyperpigmentation, and the emergence of fine lines that were previously more commonly observed in older age groups. Although aging is a multifactorial process influenced by genetic factors and other environmental exposures, an intensive digital lifestyle may represent a new risk factor that accelerates skin aging. Nevertheless, the relationship between blue light exposure from digital devices and the acceleration of premature aging has not yet been fully understood empirically, particularly in the context of everyday digital use.

From an academic standpoint, studies on skin aging have traditionally been dominated by research focusing on ultraviolet radiation as the primary factor in extrinsic aging. This line of research has produced a comprehensive understanding of the mechanisms underlying photoaging caused by sunlight exposure. However, alongside changes in modern lifestyles, sources of high-energy light exposure are no longer limited to sunlight, but also originate from digital devices used for prolonged periods on a daily basis. Several dermatological and experimental studies have begun to demonstrate that blue light can induce oxidative stress, DNA damage, and disruptions in skin cell regeneration. Despite this, these findings remain fragmented and are often derived from laboratory conditions that do not fully represent real-life daily digital exposure in humans.

In addition, quantitative research findings regarding the impact of blue light on skin aging show considerable variability. Some studies report a significant relationship between blue light exposure and changes in skin structure, while others suggest that its effects are relatively smaller compared to ultraviolet radiation. These inconsistencies indicate the presence of methodological gaps, particularly in measuring the intensity of blue light exposure and in determining appropriate indicators of premature aging. Many previous studies have assessed skin aging clinically without adequately linking it to patterns of digital device use in everyday life.

From a practical perspective, young adults constitute the group most exposed to digital devices, yet they tend to exhibit relatively low awareness of the long-term risks of blue light exposure for skin health. The use of digital devices is generally driven by considerations of convenience and productivity, while health implications are often overlooked. The lack of quantitative evidence that specifically links digital blue light exposure to premature aging has limited the development of evidence-based preventive education efforts. Such evidence is essential to encourage healthier digital device use behaviors.

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A critical review of previous research reveals that most studies emphasize the effects of blue light on sleep quality and eye health, while its impact on skin aging is frequently treated as a secondary issue. Research that explicitly measures daily blue light exposure from digital devices and examines its relationship with premature aging symptoms among young adults remains very limited. Moreover, exposure variables are often measured in a crude manner, without adequately accounting for usage duration, device type, and complex digital usage patterns. Other lifestyle factors such as sleep patterns, sunscreen use, and duration of outdoor activities are also often insufficiently controlled.

These conditions indicate the existence of a significant research gap, namely the lack of quantitative studies that systematically examine the relationship between the intensity of blue light exposure from digital devices and the acceleration of premature aging among young adults. This research gap is not only empirical but also conceptual, as there is no established analytical framework that integrates modern digital lifestyles with measurable indicators of premature aging. Without a comprehensive quantitative approach, understanding the role of blue light as a risk factor for premature aging will remain largely speculative.

Based on this gap, the novelty of this study lies in its empirical examination of the relationship between blue light exposure from digital devices and the acceleration of premature aging within the context of young adults' digital lifestyles. This study integrates measurable indicators of digital exposure, such as duration of device use and types of devices used, with systematically reported indicators of premature aging symptoms. This approach enables a more realistic analysis of the impact of digital exposure in everyday life. Accordingly, the objective of this study is to analyze the relationship between the level of blue light exposure from digital devices and the acceleration of premature aging among young adults. The findings are expected to contribute academically by enriching the literature on skin aging in the context of digital lifestyles, while also providing an empirical basis for the development of preventive health education strategies relevant to the challenges of the digital era.

METHOD

This study employed an explanatory quantitative approach with a cross-sectional design to analyze the relationship between blue light exposure from digital devices and the acceleration of premature aging among young adults. Structural Equation Modeling using the Partial Least Squares approach was applied as the analytical framework, as it allows for the simultaneous examination of relationships among latent constructs and is suitable for research involving multidimensional behavioral and perceptual variables. The study population consisted of young adults aged 18 to 35 years who actively use digital devices in their daily activities. The sample was obtained through purposive sampling, with inclusion criteria requiring respondents to regularly use smartphones, laptops, or tablets. A total of 210 respondents met the criteria and were included in the analysis, a sample size

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considered adequate for SEM–PLS analysis in survey-based social and health research.

The independent variable in this study was blue light exposure, measured based on the duration of digital device use and the types of devices used. The dependent variable was premature aging, measured through indicators of early skin aging symptoms such as skin fatigue, dullness, and the appearance of fine lines. Data were collected using a structured questionnaire with a five-point Likert scale and analyzed using SEM–PLS through stages of measurement model evaluation for validity and reliability, followed by structural model analysis to test the significance of relationships between variables at a 5 percent significance level.

RESULT AND DISCUSSION

RESULT

1. Sample Characteristic

Table 1. Respondent Characteristics

Characteristic	Category	Frequency (n)	Percentage (%)
Age	18–24 years	86	41.0
	25–30 years	74	35.2
	31–35 years	50	23.8
Daily Screen Time	≤ 4 hours	38	18.1
	5–6 hours	64	30.5
	> 6 hours	108	51.4
Main Device Used	Smartphone	193	92.0
	Laptop/PC	143	68.1
	Tablet	44	21.0

The table shows that more than half of respondents (51.4%) reported daily screen exposure exceeding 6 hours, indicating intensive digital device usage among young adults. Smartphones dominate as the primary source of exposure (92%), followed by laptops or PCs. This distribution confirms that the sample represents a population with substantial and repeated exposure to digital screens, which is relevant for examining blue light exposure effects.

2. Descriptive Statistics of Research Variables

Table 2. Descriptive Statistics of Variables

Variable	Mean	Standard Deviation	Interpretation
Blue Light Exposure	3.87	0.71	High
Premature Aging Symptoms	3.42	0.65	Moderate–High

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The mean score for blue light exposure indicates a high level of daily exposure, while premature aging symptoms fall within the moderate to high range. Respondents with screen time exceeding six hours per day consistently reported higher scores of premature aging symptoms, particularly skin fatigue, dullness, and early fine lines.

3. Measurement Model Evaluation (Outer Model)

Table 3. Convergent Validity and Reliability

Construct	Indicator	Loading	Cronbach's Alpha	Composite Reliability	AVE
Blue Light Exposure	BLE1	0.821	0.871	0.903	0.699
	BLE2	0.847			
	BLE3	0.829			
Premature Aging	PA1	0.814	0.883	0.912	0.721
	PA2	0.861			
	PA3	0.845			

All indicator loadings exceed 0.70, demonstrating strong convergent validity. Cronbach's Alpha and Composite Reliability values are above 0.70, confirming high internal consistency. AVE values above 0.50 indicate adequate convergent validity for both constructs. Thus, all measurement indicators are valid and reliable.

4. Structural Model Evaluation (Inner Model)

Table 4. R-Square Value

Endogenous Variable	R^2
Premature Aging	0.192

The R^2 value of 0.192 indicates that 19.2% of the variance in premature aging symptoms is explained by blue light exposure. This suggests a moderate explanatory power, indicating that premature aging is influenced by additional lifestyle and biological factors beyond blue light exposure.

5. Hypothesis Testing (Path Coefficient)

Table 5. Path Coefficient and Significance

Hypothesis	Relationship	Path Coefficient (β)	t-value	p-value
H1	Blue Light Exposure → Premature Aging	0.438	7.860	0.000

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The path coefficient shows a positive relationship between blue light exposure and premature aging (β = 0.438). The p-value of 0.000 (< 0.05) indicates that the relationship is statistically significant. This result confirms that higher levels of blue light exposure significantly increase premature aging symptoms among young adults. Therefore, H1 is accepted. Overall, the SEM–PLS analysis demonstrates that blue light exposure from digital devices has a significant and positive effect on premature aging symptoms. The measurement model meets validity and reliability criteria, and the structural model confirms the hypothesized relationship with statistically significant results.

DISCUSSION

The Effect of Blue Light Exposure on the Acceleration of Premature Aging among Young Adults

The findings of this study empirically support the hypothesis that blue light exposure from digital devices is positively and significantly associated with the acceleration of premature aging among young adults. This relationship is not only statistically significant but also biologically and conceptually coherent, thereby strengthening the validity of the research hypothesis. The positive path coefficient indicates that increases in the intensity and duration of blue light exposure are followed by increases in premature aging symptoms, including skin fatigue, dullness, and the early appearance of fine lines.

From a biological perspective, these findings are consistent with dermatological literature explaining that blue light carries high energy and is capable of penetrating skin layers down to the dermis. Repeated exposure can trigger oxidative stress, increase the production of reactive oxygen species, and disrupt the antioxidant balance of skin cells. These processes contribute to DNA damage, mitochondrial dysfunction, and slowed skin cell regeneration, which constitute key mechanisms in premature aging. Accordingly, the relationship identified in this study reinforces the argument that digital blue light exposure is not merely a cosmetic concern, but a biologically relevant factor in skin aging processes.

The moderate positive correlation identified in this study also has important implications for understanding the nature of premature aging. The findings indicate that blue light exposure is not the sole cause of premature aging, but rather a significant risk factor within the context of modern digital lifestyles. This aligns with the view that skin aging is multifactorial and influenced by interactions among environmental factors, lifestyle behaviors, and internal biological processes. Thus, the research hypothesis does not imply a deterministic relationship, but a realistic and proportional causal association.

From a methodological standpoint, the use of SEM–PLS strengthens the robustness of these findings, as it enables the examination of relationships among latent constructs more reliably than simple correlation analysis. The fulfillment of validity and reliability criteria in the measurement model indicates that the indicators of blue light exposure and premature aging consistently represent the

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conceptual constructs being measured. Therefore, empirical support for the research hypothesis is derived not only from statistical significance, but also from the adequacy of the measurement model. Overall, these findings confirm the primary hypothesis of the study, namely that blue light exposure from digital devices constitutes a meaningful contributing factor to the acceleration of premature aging among young adults. This confirmation addresses gaps in previous research that predominantly focused on ultraviolet exposure, by providing quantitative evidence that digital light sources also have significant implications for skin health.

Implications of Daily Digital Exposure for Skin Health and Preventive Behavior

The results of this study further reinforce the hypothesis that daily digital exposure has significant implications for skin health among young adults, not merely as a technological phenomenon but as a lifestyle-related health risk. From the perspective of preventive health theory, blue light exposure can be conceptualized as a chronic low-dose environmental stressor, characterized by low intensity but repeated and cumulative exposure. This characteristic explains why the effects of blue light exposure are not always immediately observable, yet contribute to the acceleration of premature aging over the medium term.

Theoretically, the life-course health perspective emphasizes that the accumulation of risk exposures from a young age can influence health conditions later in life. The findings of this study are consistent with this framework, as young adults experiencing intensive digital exposure may enter later stages of biological aging with skin conditions that have already undergone earlier functional degradation. Consequently, the research hypothesis is not only statistically relevant, but also aligned with long-term health theories that underscore the importance of early prevention. In addition, from the standpoint of health behavior theory, the low level of awareness among young adults regarding the risks of blue light exposure can be explained through the concept of perceived susceptibility. Young adults tend to view aging as a distant concern, resulting in digital exposure risks to skin health being perceived as non-urgent. The findings of this study support the argument that the imbalance between high exposure and low risk perception accelerates the accumulation of negative effects associated with blue light exposure. Accordingly, the research hypothesis underscores that digital exposure is not merely a technical issue, but is closely related to individual health perceptions and behaviors.

In this context, the coefficient of determination indicating the contribution of blue light exposure to premature aging confirms that, although aging is multifactorial, digital exposure plays a clear empirical role. This finding strengthens the positioning of blue light exposure as a modifiable risk factor, namely a risk factor that can be managed through behavioral change. Therefore, confirmation of the research hypothesis provides a strong theoretical and empirical foundation for the development of preventive strategies, including regulation of screen time, utilization of blue light protection technologies, and digital health education integrated with the promotion of healthy lifestyles.

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CONCLUSION

This study concludes that blue light exposure from digital devices is positively and significantly associated with the acceleration of premature aging among young adults. The intensity and duration of digital device use are shown to contribute to the emergence of early skin aging symptoms, such as skin fatigue, dullness, and early fine lines. These findings confirm that blue light exposure represents a relevant modern lifestyle risk factor, even though premature aging is multifactorial and influenced by various biological and environmental determinants.

Theoretically, the results strengthen the understanding that blue light exposure can be positioned as a chronic low-dose environmental stressor that is cumulative in nature and produces medium-term effects. Practically, this study recommends the adoption of evidence-based preventive approaches, particularly among young adults, through the regulation of screen time, the use of blue light protection features, and the enhancement of digital health literacy. Future research is encouraged to employ longitudinal designs and to incorporate biological and lifestyle factors simultaneously in order to achieve a more comprehensive understanding of the long-term effects of blue light exposure.

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