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Studying the effect of ultraviolet C radiation on the fine structure of rat skin tissue and blood analysis using transmission electron microscopy

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دراسة تأثير الأشعة فوق البنفسجية من النوع C على التركيب الدقيق لنسيج جلد الجرذان وتحليل الدم باستخدام المجهر الإلكتروني النافذ

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Abstract

This study aimed to evaluate the ultraviolet-C (UVC) effects of radiation on the skin of Wistar rats and its impact on blood parameters. Forty adult rats were used, divided into a control group and three experimental groups exposed to artificial UVC (254 nm) radiation for 8, 16, and 24 days, 8 hours per day. Transmission electron microscopy results showed progressive damage to skin cells with increasing exposure time, including: nuclear envelope irregularities, mitochondrial swelling, increased melanin granule accumulation, keratinocyte and collagen filament disruption, and widening of cell junctions. In addition, blood analysis revealed significant changes in blood parameters: decreased hemoglobin and red blood cell (RBC) levels with longer exposure, as well as changes in white blood cell (WBC) levels, with statistical significance at $p < 0.05$. These results confirm the harmful effects of UVC radiation on the skin and blood, and reflect the relationship between exposure duration and biological changes, highlighting the importance of taking precautionary measures when using UVC radiation industrially.

Keywords: Ultraviolet C radiation, Rat skin, Ultrastructural microscopy, Transmission electron microscopy, Blood analysis.

الملخص

هدفت هذه الدراسة إلى تقييم تأثير الأشعة فوق البنفسجية من النوع C (UVC) على جلد جرذان ويستار وتأثيرها على مؤشرات الدم. استُخدم أربعون جرذاً بالغاً، قُسمت إلى مجموعة ضابطة وثلاث مجموعات تجريبية تعرّضت لأشعة UVC صناعية (بطول موجي 254 نانومتر) لمدة 8 و16 و24 يوماً، بمعدل 8 ساعات يومياً.

أظهرت نتائج المجهر الإلكتروني النافذ حدوث تلف تدريجي في خلايا الجلد مع زيادة مدة التعرض، تمثل في: عدم انتظام الغلاف النووي، تورم الميتوكوندريا، زيادة تراكم حبيبات الميلانين، تضرر الخلايا الكيراتينية وألياف الكولاجين، واتساع الوصلات بين الخلايا.

بالإضافة إلى ذلك، أظهر تحليل الدم تغيرات معنوية في معاييره؛ حيث لوحظ انخفاض في مستوى الهيموغلوبين وعدد كريات الدم الحمراء (RBC) مع زيادة مدة التعرض، فضلاً عن تغيرات في عدد كريات الدم البيضاء (WBC)، مع دلالة إحصائية عند مستوى ($p < 0.05$).

تؤكد هذه النتائج التأثيرات الضارة لأشعة UVC على الجلد والدم، كما تعكس العلاقة بين مدة التعرض والتغيرات البيولوجية، مما يبرز أهمية اتخاذ التدابير الوقائية عند استخدام أشعة UVC في التطبيقات الصناعية.

الكلمات المفتاحية: الأشعة فوق البنفسجية من النوع C، جلد الجرذان، المجهرية فائقة الدقة، المجهر الإلكتروني النافذ، تحليل الدم

Introduction

Radiation is energy that travels in the form of waves or particles, and is classified as ionizing or non-ionizing radiation. Ultraviolet (UV) radiation is non-ionizing radiation, and is characterized by its strong biological effects due to its short wavelength and high energy [1]. Ultraviolet (UV) radiation has a wavelength range of 100–400 nm and is divided into UVA (315–400 nm), UVB (280–315 nm), and UVC (100–280 nm). UVC radiation is the most energetic and the most damaging to living organisms. Although most of it is absorbed by the ozone layer, the increasing industrial use of UVC sources for sterilization may increase the risk of harmful effects on skin and blood [2]. The known effects of UVC radiation include mitochondrial damage, nuclear envelope disruption, melanin accumulation, and cytoskeletal disruption. Recent studies have also indicated UVC effects on blood parameters, including decreased hemoglobin and red blood cell counts, and changes in white blood cells [3]. Previous studies have shown the effects of UVA and UVB on skin and blood, but data regarding the ultramicroscopic effects of UVC on skin cells and blood analysis are limited, calling for studies like this to understand the cellular mechanisms and biological changes [4]. Therefore, this study aimed to evaluate the effect of UVC exposure on the ultramicroscopic structure of rat skin and blood using transmission electron microscopy, focusing on the relationship between exposure duration and changes in cells and blood.

Materials and Methods

Experimental Animals

Forty adult Wistar rats, weighing between 180 and 200 grams, were used in the laboratory for 24 days of acclimatization at a constant temperature (20 ± 2 °C), with free access to food and water.

UV Radiation Exposure

The rats were placed in individual terrariums, and a 15 W UVC lamp, 45 cm long, was installed. The radiation intensity measured at a distance of 30 cm was 4.02 $J/cm^2/s$, with an exposure time of 8 hours per day.

The rats were divided into four groups:

- Control group: No radiation exposure
- Group 2: 8 days of exposure
- Group 3: 16 days of exposure
- Group 4: 24 days of exposure

Preparation for Transmission Electron Microscopy

After the exposure period, the rats were anesthetized, and skin samples were excised and cut into small sections. The samples were fixed in glutaraldehyde, then 1% osmium tetraoxide. They were dried with a graded series of ethanol, dehydrated with propylene oxide, and embedded in Araldite CY-212 resin. Ultrathin sections were prepared using an ultramicrotome, stained with uranyl acetate and lead citrate, and examined using a JEOL JEM 100 CX-II transmission electron microscope.

Blood Sample Collection and Analysis

Blood samples were collected before and after exposure periods (8, 16, and 24 days). Hemoglobin (Hb), red blood cell (RBC), and white blood cell (WBC) were analyzed, and the results were compared with the control group using statistical analysis ($p < 0.05$).

Ethical Considerations

All procedures followed institutional ethical guidelines with informed consent from participants.

Results

1. Transmission Electron Microscopy (TEM) Results of Rat Skin Sections

_ Table 1: Transmission Electron Microscopy (TEM) images of rat skin sections

Exposure Period	Nuclear Coating	Mitochondria	Melanin	Special Cells	Collagen Fibers	General Observations
Control	Regular	Intact	Normal	Normal	Regular	Normal structure
8 Days	Mild disturbance	Mild swelling	Slight increase	Langerhans cells	Slightly irregular	Mild changes
16 Days	Irregular	Moderate swelling	Increased accumulation	Distribution disturbance	Disorganized	Moderate damage
24 Days	Severely disturbed	Marked damage	Heavy accumulation	Deformed cells	Fragmented and disorganized	Severe damage

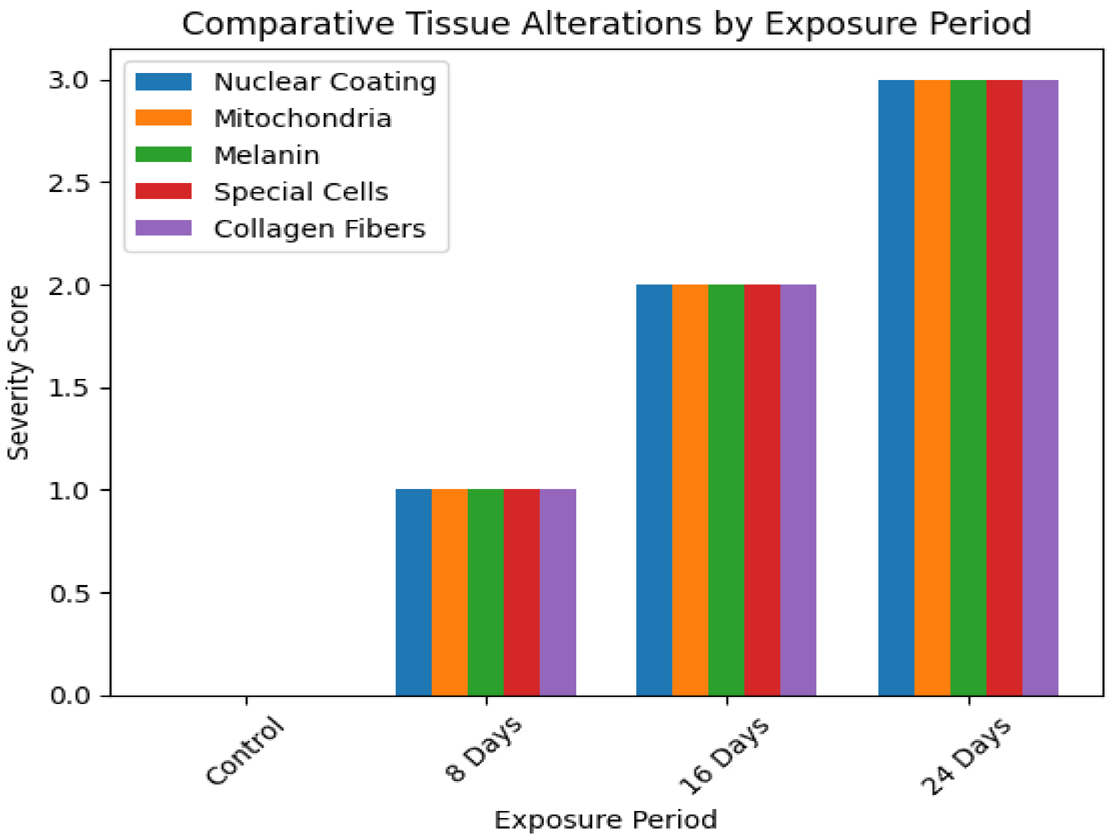


_Figure 1: Transmission Electron Microscopy (TEM) images of rat skin sections

A: Normal skin — clear nuclei, intact mitochondria, evenly distributed melanin granules, and regular collagen fibers.

B: After 8 days — mild mitochondrial swelling, slight disturbance of the nuclear envelope, and beginning accumulation of melanin granules.

C: After 16 days — increased melanin granule accumulation, appearance of cytoplasmic vacuoles, irregular nuclei, and disturbance of keratinocytes.

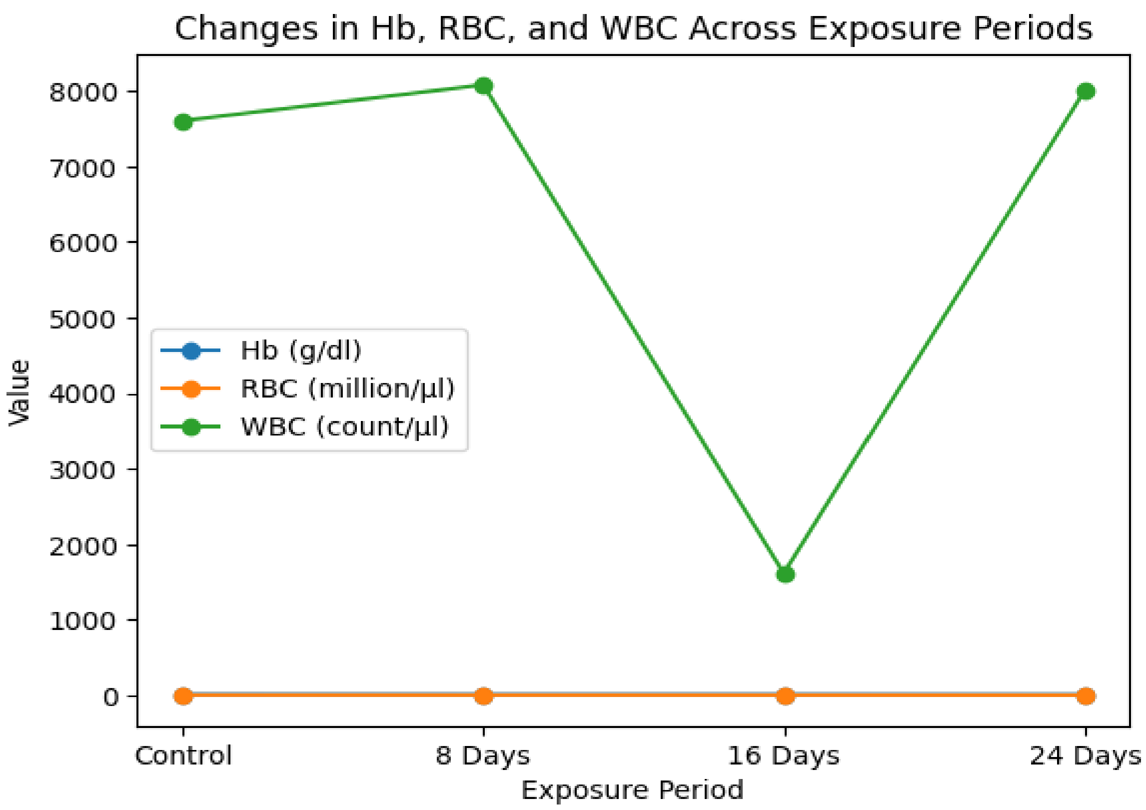
D: After 24 days — severe damage in the basal layer and dermis, increased melanocytes, disorganization of collagen fibers, and widening of intercellular junctions._

2. Blood Analysis Results

_Table 2: Blood Analysis Results

Exposure Period	Hb (g/dl)	RBC (million/μl)	WBC (count/μl)
Control	12.90–12.29	4.90–4.62	8670–6540
8 Days	11.58	4.15	8080
16 Days	11.47	3.83	1616
24 Days	10.18	3.30	8008

_ Table 2: Blood Analysis Results



_ **Figure 2: Blood Analysis Results**

The results indicate a decrease in Hb and RBC with increased UVC exposure, and significant changes in WBC, reflecting the toxic effects on blood cells.

Discussion

The present study demonstrated that ultraviolet-C (UVC) radiation induces time-dependent ultrastructural damage in rat skin tissue accompanied by significant hematological alterations, indicating that UVC exposure exerts both localized tissue injury and systemic biological effects.

1. Ultrastructural Skin Damage

Transmission electron microscopy revealed progressive cellular deterioration with increasing exposure duration, suggesting a cumulative cytotoxic effect of UVC radiation. The observed nuclear envelope irregularities are indicative of DNA stress and disruption of nuclear integrity. UVC radiation at 254 nm is strongly absorbed by nucleic acids, leading to the formation of cyclobutane pyrimidine dimers (CPDs) and DNA photoproducts, which interfere with transcription and replication processes. This explains the nuclear deformation and chromatin condensation seen in prolonged exposure groups.

Mitochondrial swelling is a hallmark of oxidative injury. UVC exposure is known to generate reactive oxygen species (ROS), which damage mitochondrial membranes, impair ATP production, and activate intrinsic apoptotic pathways. The progression from mild swelling in early exposure to severe mitochondrial disruption at 24 days suggests a transition from reversible stress to irreversible cellular injury.

The increase in melanin granules likely represents a protective adaptive response. Melanin functions as a natural photoprotective pigment that absorbs UV radiation and scavenges free radicals. However, excessive accumulation may reflect melanocyte hyperactivity secondary to chronic radiation stress rather than effective protection.

Disruption of keratin filaments and collagen fibers indicates damage to both epidermal cytoskeletal integrity and dermal extracellular matrix structure. Collagen degradation may be mediated by ROS-induced activation of matrix metalloproteinases (MMPs), leading to dermal weakening. The widening of intercellular junctions further suggests compromised barrier function, increasing susceptibility to inflammation and secondary tissue injury.

Together, these findings confirm that UVC exposure affects multiple cellular targets: DNA, mitochondria, cytoskeleton, and extracellular matrix.

2. Hematological Changes

A significant decline in hemoglobin (Hb) and red blood cell (RBC) counts was observed with increasing exposure duration. This may result from:

Oxidative damage to erythrocyte membranes leading to hemolysis

Suppression of bone marrow erythropoiesis due to systemic oxidative stress

Direct photobiological effects on circulating cells

Erythrocytes are particularly sensitive to oxidative stress because of their high oxygen content and membrane polyunsaturated fatty acids. Lipid peroxidation may explain reduced RBC survival.

The alterations in white blood cell (WBC) counts reflect immune system involvement. Early exposure may stimulate leukocyte mobilization as a stress response, while prolonged exposure (notably the 16-day group) may indicate immune suppression or redistribution of leukocytes to damaged tissues. UV radiation is known to modulate immune responses by altering cytokine release and inducing systemic inflammatory signaling.

These blood findings demonstrate that UVC radiation effects are not limited to the skin but extend to systemic physiological processes.

3. Relationship Between Exposure Duration and Damage Severity

A clear dose–time relationship was evident. Mild ultrastructural changes at 8 days progressed to severe nuclear, mitochondrial, and connective tissue damage by 24 days. This supports the concept of cumulative phototoxicity, where repeated sublethal injury overwhelms cellular repair mechanisms.

DNA repair systems, antioxidant defenses, and cellular turnover may initially mitigate damage, but chronic exposure likely leads to oxidative imbalance, apoptosis, and structural degeneration.

4. Comparison with Previous Studies

The present findings align with previous reports describing:

UV-induced mitochondrial and nuclear alterations

Collagen degradation and cytoskeletal disruption

Hematological oxidative stress markers

However, most earlier studies focused on UVA and UVB. The current work provides ultrastructural evidence specific to UVC, which is less studied but increasingly relevant due to its industrial and sterilization uses.

5. Biological and Occupational Implications

Although natural atmospheric absorption limits environmental UVC exposure, artificial sources are widely used in medical sterilization, laboratories, and industry. The demonstrated cellular and blood toxicity underscores the importance of:

Shielding and protective clothing

Exposure time control

Occupational safety regulations

6. Study Limitations

Lack of biochemical oxidative stress markers (e.g., MDA, SOD, catalase)

Absence of bone marrow examination

No molecular assays for DNA damage

Future studies should integrate molecular, biochemical, and immunological analyses to better define mechanisms.

7. Overall Interpretation

This study demonstrates that UVC radiation induces multilevel biological injury involving:

Nuclear and mitochondrial damage

Cytoskeletal and connective tissue disruption

Hematological toxicity

These effects intensify with exposure duration, indicating that UVC radiation acts through oxidative stress, DNA damage, and structural protein degradation, ultimately impairing both tissue integrity and systemic health.

The results show that UVC radiation causes progressive damage to skin and blood cells with increasing exposure time [5]. Skin microscopic analysis revealed disruption of membranes and organelles, melanin accumulation, and cytoskeletal disturbances, while blood samples showed decreased hemoglobin and red blood cell counts, and changes in white blood cells, reflecting the radiation's impact on multiple biological functions [6,7].

These findings are consistent with recent literature demonstrating that UVC radiation, despite its sterilizing benefits, causes significant damage to skin and blood [8,9].

Conclusion

• UVC radiation causes distinct ultramicroscopic changes in rat skin, depending on the duration of exposure.

• Prolonged exposure leads to severe damage to skin and dermal cells.

• UVC radiation causes significant changes in blood, including decreased hemoglobin and red blood cell counts, and altered white blood cell counts.

• These findings underscore the need to limit industrial exposure to UVC radiation and implement strict protective measures.

References

1. V. O. Melnikova and N. H. Ananthaswamy, "Cellular and molecular events leading to the development of skin cancer," Mutation Research, vol. 571, pp. 91–106, 2005..
2. World Health Organization, Ultraviolet Radiation, Environmental Health Criteria 160. Geneva, Switzerland: World Health Organization, 1994.
3. R. McKenzie, L. Björn, A. Bais, and M. Ilyas, "Changes in biologically active ultraviolet radiation reaching the Earth's surface," Photochemical & Photobiological Sciences, 2003.
4. J. Ravindran, A. Indrajith, K. P. Pratheesh, C. Sanjiviraja, and V. Balakrishnan, "Ultraviolet radiation induced biological effects," Journal of Environmental Biology, 2010.
5. C. Karampasi, I. Sfiniadakis, A. Petri, and M. Rallis, "Dermatological effects of acute and long-term UV-C exposure: an in vivo study using a portable mercury lamp," Photochemical & Photobiological Sciences, 2025.

6. "Ultraviolet Radiation: Biological and Medical Implications," Critical Reviews in Molecular Biology, 2024.
7. D. Koumaki, G. Evangelou, S. Gregoriou, et al., "Skin cancer knowledge, sun exposure, photoprotection behavior, and perceived barriers in a Greek cohort," Cancers, vol. 16, no. 24, 2024.
8. "Current insights and future perspectives of ultraviolet radiation (UV)," Environmental Research, 2024.
9. "Extending the acute skin response spectrum to include the far-UVC," Photochemistry and Photobiology, 2024.