LIGHT-INDUCED CHANGES IN THE RETINA OF ALBINO RATS

Structural and quantitative studies

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Introduction

Exposure to light seems to play a key role in some age-related retinal diseases, especially macular degeneration, probably by inducing cell death, oxidative stress, or the expression of several genes. However, it is still unclear which part of the visual spectrum is responsible for these changes. The present study was designed to investigate the effects on the retina of continuous exposure to white-light, or to white-light filtered to eliminate the yellow (blue light) or blue (yellow light) portions of the visual spectrum.

Under certain circumstances, light is capable of causing the death of the photoreceptors and cells of the retinal pigment epithelium through apoptosis and through a mechanism involving rhodopsin [1, 2].

Lipofuscin is a nondegradable by-product of compound degradation found in cell lysosomes that builds up with age and cell damage. Lipofuscin appears mainly in cells of the pigment epithelium and derives from the products of phagocytosis of the outer photoreceptor segments. This substance contains several fluorogens that absorb light and emit yellow-orange autofluorescence when stimulated with blue light. Since light stimulation of lipofuscin generates oxidizing substances, it has been proposed that lipofuscin mediates the phototoxic effects of light on the retina. Further, lipofuscin produces more oxidizing substances when stimulated with blue light (short wavelengths), which is known to be more phototoxic [1].

Materials and Methods

- Population sample
  - 24 adult Wistar-Kioto rats → Divided into 3 groups of 8 animals
  - Exposure to different wavelengths of light for 15 days
  - Anaesthesia: intraperitoneal ketamine hydrochloride (350 mg/kg). Subsequent sacrifice by rapid decapitation
  - Removal of ocular globes
- Light
  - Exposure to white, blue and yellow radiation for 15 days (12 hours/day)
  - Radiation
    - White: equivalent to solar radiation
    - Yellow: light lacking blue radiation (50% transmission at 450 nm)
    - Blue: radiation at wavelengths under 500 nm (50% transmission at 446 nm)
- Histological sections
  - Fixing ocular globes in 10% formaldehyde for 24 hours. Embedding in paraffin using standard procedures.
  - Histological sections 10 µm
  - Slides treated with Aptex® adhesive (3-aminopropyl-triethoxysilane, Sigma)
- Stains
  - Haematoxylin-eosin
  - 10 sections per animal (10 µm separation between cuts)
  - Retinal sections at the macula could not be obtained
- Quantitative determinations
  - Outer granular or nuclear layer: nuclear density (determining rods and cones)
  - Inner granular or nuclear layer: nuclear density (determining bipolar neurons essentially)
  - Ganglion cell layer: ganglion cell density.

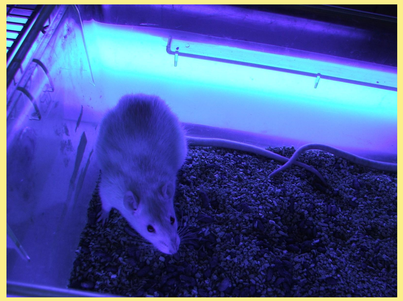

Figure 1: rat exposure to blue light

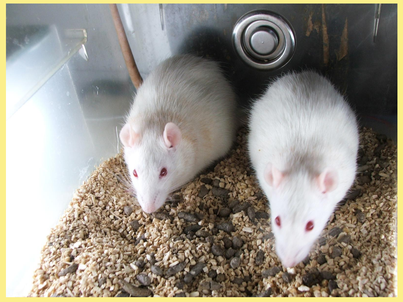

Figure 2: rats exposure to blue white light

Results and Discussion

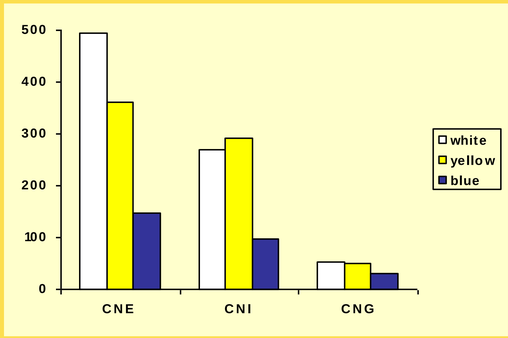

Figure 3 shows the results of the quantitative analysis performed on the three retinal layers in histological sections of specimens from the three study groups (white, yellow and blue light).

Figure 3.- **Cell densities** obtained for the three groups of animals corresponding to the outer **nuclear** layer **(ONL),** inner **nuclear** layer **(INL)** and ganglion cell layer **(GCL).**

Figure 4 shows that exposure to white light fails to modify the structure of the retina. In contrast, the retina of rats exposed yellow light shows a reduction in the thickness of the outer plexiform layer, reduced cell numbers in the inner and outer granular layers, and the occasional absence of the external segments of the photoreceptors (Figure 5).

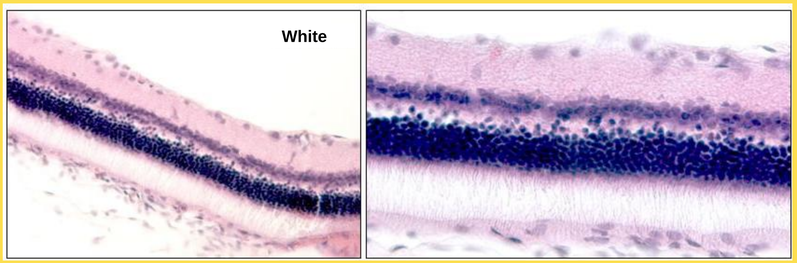

Figure 4.- Structure of the retina of Wistar-Kioto rats subjected to white light for 15 days. Note the lack of pigmentation in the retinal pigment epithelium.

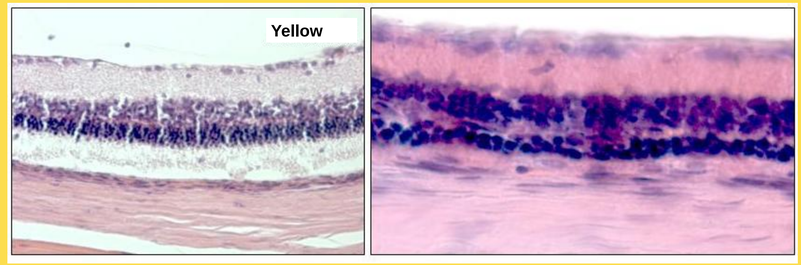

Figure 5.- Structure of the retina of Wistar-Kioto rats subjected to yellow light for 15 days. These images show the reduced thickness of the outer plexiform layer. The image on the right shows the absence of the outer segments of the photoreceptors and the reduced cellularity of the granular layers.

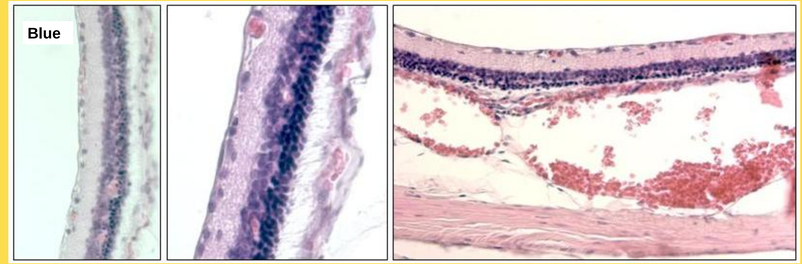

Figure 8.- Structure of the retina of Wistar-Kioto rats subjected to blue light for 15 days. Both images indicate the reduced thickness of the outer plexiform layer, the lack of photoreceptor outer segments and large blood vessels in the choroids of extensive areas of the eye.

The present results demonstrate that exposure to light, especially blue light, causes deleterious changes in the retina. This involves mainly photoreceptors but also neurons, and claims for a direct noxious effect of light on the retina. Also, they suggest that the sensitivity of the retina to light is not influenced as much by the color than by the amount of light [3,4] and this confirms that blue light has phototoxic effects more potent than yellow light [2].

In addition to the retinal changes, blue light produces disarrangement of the retinal-choroidal junction with dilatation of choroidal blood vessel responsible for indirect retinal damage.

Conclusions

The structural retinal changes induced by blue light exposure can be partly prevented by using yellow filters, blocking of the transmission of blue light. This is in agreement with previous data reported in the albino rat using yellow lens [5]. Therefore, the use of lens capable to filter blue light might be of interest in the prevention and treatment of age-dependent macular degeneration, retinitis pigmentosa and other retinal diseases.

References

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