Blue Light and Smart Phones

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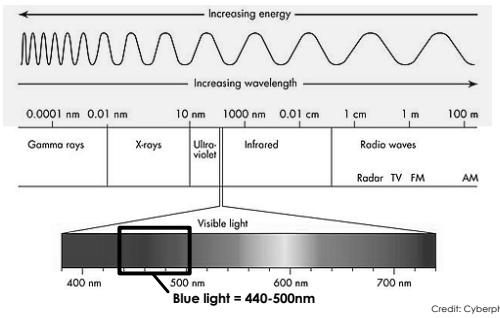
Learning Objectives:

By the end of this course, the learner should be able to:

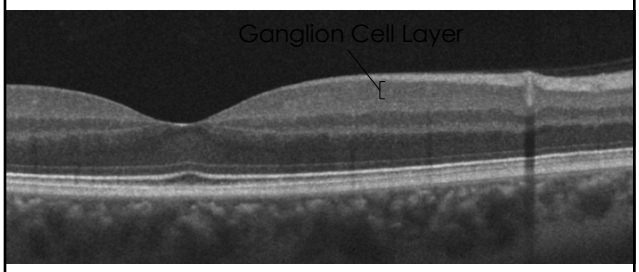
- Describe the natural circadian rhythm of the human body.
- Explain the impact of blue light on sleep patterns.
- Discuss the current understanding of the effects of blue light on the retina.
- Understand levels of environmental and synthetic blue light exposure.
- Identify methods to avoid or mitigate blue light exposure.



Credit: Cyberphysics.co.uk

Blue Light and Sleep

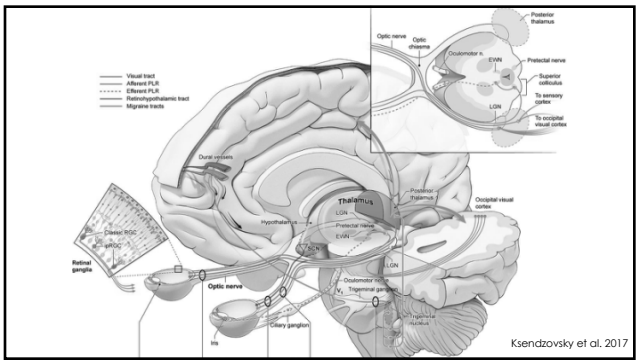
- Sleep cycle starts with intrinsically photosensitive retinal ganglion cells (ipRGCs)
  - Make up 3-5% of mammalian RGCs
  - Contain the photo pigment melanopsin
  - Melanopsin is stimulated by 420-480nm light (in blue spectrum).
- These cells are used for non-image-forming photoreception.
  - Circadian photoentrainment
  - Pupillary light response
- Mice lacking rods and cones still demonstrated a pupillary light reflex and able to sync circadian rhythms to light-dark cycles.



Credit: OCTMD.org

Blue Light and Sleep

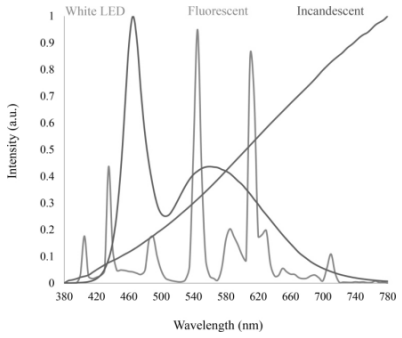
- Two types of ipRGCs (M1 and M2 cells).
- M1 cells - retina to the hypothalamus (suprachiasmatic nucleus)
  - Photoentrainment of circadian rhythm
  - Inhibition of melatonin release
  - Control of locomotor activity
  - Sleep regulation
  - Metabolic rate
  - Mood
- M1 and M2 cells - retina to the olivary pretectal nucleus



Ksendzovsky et al. 2017

Blue Light and Sleep

- LEDs are the primary light source in most back-lit screens today (phones, tablets, many TVs).
  - Physically small
  - Brighter
  - Low power use
- We are using more back-lit screens (direct illumination) vs paper (reflected illumination).



Blue Light and Sleep

- Circadian rhythm is determined by amplitude of light-dark cycle – both intensity of daytime exposure and low levels of light in evening.
- Van der Maren et al. 2018
  - Case-control of 14 young adults with delayed sleep pattern to 14 controls with normal sleep pattern.
  - Subjects wore photometers to measure light exposure and kept logs of use of light-emitting devices.
  - Found the delayed sleep onset cases had less daytime exposure to (blue-rich) outdoor light and increased use of light-emitting devices in the 3 hours before bedtime.

Blue Light and Sleep

- Viola 2008 – Exposure to blue-enriched light in the workplace increased subjective daytime alertness and sleep quality measures.
- The lens grows thicker and more yellow through life leading to increased absorption of blue light
  - 53 y/o lens absorbs 30% and a 75 y/o lens absorbs 75% of blue light
- Zheng et al. 2017 - Meta-analysis demonstrated improved sleep quality after cataract surgery.

Blue Light and the Retina

- Photochemical damage
  - Light absorption by the RPE increases ROS (free radicals) which causes oxidative stress on the RPE.
  - Blue light has a shorter wavelength and therefore higher energy levels – more damage to RPE cells.
  - Moon 2017 – light from display devices on cultured retinal pigment epithelial (RPE) cells triggered cell apoptosis.
- Blue light exposure also leads to accumulation of toxic metabolic byproduct lipofuscin in RPE.
- Lipofuscin itself produces free radicals when exposed to blue light.

Blue Light and the Retina

- Age-related macular degeneration is associated with similar accumulation of lipofuscin and associated toxicity to the RPE.
- Beaver Dam Eye Study – 2764 pts – higher risk in pts who were exposed to 5 hrs/d of summer sun in their teens-30's were more likely to develop early AMD than those with <2 hrs/d. Those with 5 hrs/d but wearing hats/sunglasses at least 50% of the time were less likely to have these changes.
- Darzins et al. 1997 – Australia - Case-control compared 409 pts with AMD with 286 controls and found greater sun exposure in the controls.

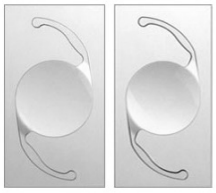
Blue Light and the Retina

- O'Hagan et al. examined light from multiple devices at maximum brightness compared to natural outdoor light levels
  - Lower light levels from all devices than natural exposure – even on a cloudy December day in the UK
  - Brightest smartphone screen demonstrated 0.38% of the ICNIRP exposure limit.
- Risk of blue light exposure is difficult to assess:
  - Concurrent UV light exposure
  - Cumulative light exposure
  - Individual susceptibility

Other impacts

- Blue light exposure can worsen dry eye
- Blue light is scattered more by atmospheric particles smaller than the wavelength of light (Rayleigh scattering)
  - Blue light is the predominant cause of glare sensitivity.

Blue-filtering IOLs



- Almost all implantable IOLs currently block UV light (<420nm)
- Blue-light filtering IOLs (BF-IOL) block up to 500nm light.
- Scotopic (dim lighting) vision depends on rods which are sensitive to short wavelength light.
  - Blocking this light decreases night vision sensitivity by 14-21%.
  - Concern that this might increase risk of falls, etc.
- BF-IOL does not impact sleep quality.
- Low quality evidence might support decreased risk of AMD progression

Blue-blocking spectacle lenses

- Meta-analysis by Lawrenson et al. demonstrated no high-quality clinical trials performed to date
- No significant difference in symptoms of eyestrain/fatigue after computer screen tasks
- No loss of contrast sensitivity or color vision
- No difference in sleep quality in normal participants
- In pts with sleep difficulty, wearing high blue-blocking lenses for 3 hours prior to sleep significantly improved self-reported sleep quality

Night Mode

- Alters color temperature of display to reduce blue light exposure.
- Not clear that actual wavelengths are being shifted.
- Adjustable by user – what level is effective?
- May be more effective to simply use lowest possible brightness.

Summary

- Subsets of RGCs are exquisitely sensitive to blue-light to coordinate multiple critical bodily functions.
- Exposure to artificially high levels of blue light may alter circadian rhythms.
- Impact of artificial blue light on retinal health is unclear.
- Multiple methods to reduce blue light exposure are available but with unknown impact on ocular and retinal health.

References

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