Light and Health

KISS 2022

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Disclosure Statement:
Nothing to disclose

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Light and Health

Light is important for human health.

Lighting in our current built environment generally provides light for visibility at the expense of our circadian system.

This will be an overview of current knowledge and research into light and health including recommendations for our patients to better balance the twin needs of light for sight with lighting to support our circadian system.

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Chronobiology

Biological rhythms are cyclic changes influenced by exogenous factors and endogenous rhythms

Any biological rhythm with a periodicity of approximately 24 hours is called a circadian rhythm

We have circadian oscillators in all cells of the body

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Circadian Rhythm (CR)

Circadian rhythms are generated by an internal clock or pacemaker

They persist in the absence of exogenous rhythms

The internal clock that regulates the circadian rhythms is synchronized or entrained to the light-dark cycle by external stimuli called Zeitgebers (time givers) which coordinate our internal clocks

The entraining agents can reset or phase shift circadian rhythms (phase advance and phase delay)

Our principal Zeitgeber is Light

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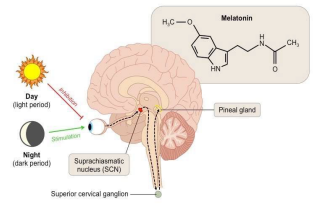
Pacemaker or Circadian Clock

Pacemaker is located in the suprachiasmatic nuclei (SCN) of the hypothalamus in the brain

The SCN is the major site of termination of the photic entrainment pathway - the retinohypothalamic tract (RHT)



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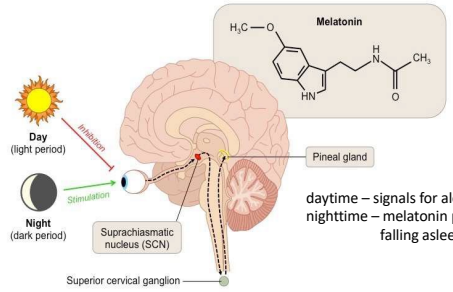

daytime – signals for alertness
nighttime – melatonin production for falling asleep/staying asleep

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RETINA

Intrinsically photosensitive retinal ganglion cells or ipRGCs contain the photopigment Melanopsin

Melanopsin cells in mammals are specialized for

- measuring ambient illumination
- contributing to visual discrimination
- drive a variety of physiological responses including
  - synchronization of circadian clocks to light-dark cycles
  - regulation of pupil size
  - modulation of sleep
  - suppression of pineal melatonin production

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RETINO-HYPOTHALAMIC TRACT (RHT) and SCN

RHT is a photic neural input pathway

The origin is the ipRGCs which contain the photopigment melanopsin

The axons of the ipRGCs belonging to the RHT project to the SCN via the optic nerve and optic chiasm

The suprachiasmatic nuclei receive and interpret information on environmental light, dark and day length for entrainment of the "body clock"

SCN nuclei direct the pineal gland to secrete the hormone melatonin

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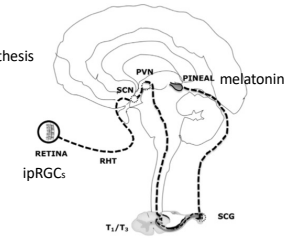
Retina > RHT > SCN>Melatonin in Pineal Gland

Neural control of pineal melatonin synthesis
RHT: retinohypothalamic tract.
SCN: suprachiasmatic nucleus
PVH: paraventricular nucleus.
SCG: superior cervical ganglion



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Functions of the Pineal Gland

Production of Melatonin

Cardiovascular Health - melatonin produced by the pineal gland can have a positive impact on your heart and BP

Mood Disorders - a lower pineal gland volume may increase your risk of developing schizophrenia and other mood disorders

Cancer - a recent study on rats found evidence that lowering pineal gland function through overexposure to light led to cellular damage and increased risk for colon cancer

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Melatonin Receptors

Highest density of receptors in the SCN, anterior pituitary and retina

Melatonin enhances $GABA_A$ receptor function in SCN which may be responsible for the regulatory effects of melatonin on mammalian circadian time-keeping and it's sleep-inducing effects

Melatonin receptors are differently expressed in different tissues (SCN, hippocampus, cerebellum, medulla, midbrain, neocortex, hypothalamus)

physiological significance of melatonin receptors in some brain regions is still unknown

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MELATONIN

Melatonin protects against oxidative stress
- Free radical scavenger
- Stimulates the synthesis of antioxidative enzymes
- Inhibits activity of free radical generating enzymes
- Protects nuclear DNA from oxidative damage

Exogenous melatonin is a zeitgeber to synchronize circadian rhythm and promote sleep onset

Melatonin production is inhibited by even low levels of light

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Melatonin

Melatonin can be used to improve sleep parameters in patients suffering from insomnia
- Circadin is a drug that is a prolonged release melatonin
  - it is used in Europe for treatment of insomnia >age 55

Hetlioz (tasamelteon) by Vanda is used to treat non-24 sleep-wake disorder
- it is a melatonin receptor agonist, used in blind > age 16

These medications are generally taken several hours before sleep

Take care re indiscriminate use – beverages, OTC with lack of quality control

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Melatonin and Alzheimer's Disease (AD)

Melatonin decreases during aging

Patients with AD have a more profound reduction in melatonin

Melatonin supplementation
- improves sleep
- ameliorates sundowning (greater late day agitation)
- slows the progression of cognitive impairment

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Circadian Rhythm

Effect on all body systems
- metabolism/weight – regulation of blood sugar and cholesterol
- mental health – depression, bipolar disorder
- dementia and other neurodegenerative diseases
- DNA repair – prevents cancer
- influences the effectiveness of anti-cancer drugs

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Disruptions to Circadian Rhythm

Jet Lag
- pre-flight phase advance for eastward travel
- pre-flight phase delay for westward travel

Shift Work
- fundamental misalignment between the circadian rhythm of the endogenous biological clock and the timing of the sleep/wake cycle
- this misalignment increases the risk of workplace accidents/injuries

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Disruptions to Circadian Rhythm

Advanced Sleep Phase Disorder (rare)
- seen in elders in nursing facilities
- use evening light therapy to delay the sleep phase

Delayed Sleep Phase Disorder – 16% of teens
- delayed bedtime and impaired ability to wake early
- advance the circadian rhythm with 2500 lux white light x 2h early AM and restrict light after 4pm

Non-24 Sleep-Wake Disorder – primarily in blind individuals
- sleep hours shifted backward (min/hours)

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Disruptions to Circadian Rhythm

Irregular Sleep-Wake Rhythm Disorder
- no consistent pattern to sleep
- person naps or sleeps for short periods
- frequently connected to brain disorders such as
  - dementia and traumatic brain injury

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How to Maintain a Healthy Circadian Rhythm

2 hours of sunlight in the morning
Daily exercise
Avoid caffeine especially after noon time
Limit light before bed
Consistent sleep schedule / darkened room
Use yellow/red/orange/amber light at bedside or nightlights
Think about circadian effective light
- blue in the morning (red light has no effect on circadian clock)

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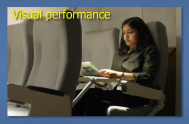
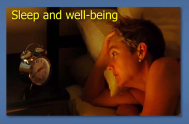
Why should we illuminate?

- Visual performance *and* sleep and well-being





- Good lighting can do both and still be energy efficient

Icahn School of Medicine at Mount Sinai — Light and Health Research Center

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THANK YOU

International **Day of Light**

16 May

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