



Original Article

Effective usage of Led bulbs and Artificial Lights: Its Pathophysiological considerations on Sleep and Human health

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ABSTRACT

Objective and Study Design: This was a cross-sectional study purposed to observe the effects of led bulbs and artificial lights on human health and its physiological considerations on sleep. Our study addressed two goals. Our first goal was to determine the extent to which light pollution was perceived as a problem by the people. Our second goal was to recommend applicable lighting ordinances for reducing light pollution. **Material and Methods:** This study was conducted at All India Institute of Medical Sciences hospital, Bhopal and Narayana medical college, Nellore during the period between May 2014 and August 2015. Three hundred human volunteers, 123 female and 177 male, ages of 18 and 55 were studied in a two-part experiment, which included one Sleep questionnaire regarding light pollution to study each individual's normal body conditions, and one Assay of melatonin in saliva. **Results:** The results showed that many participants have a long history of sleeping problems. They usually take at least an hour to fall asleep and tend to wake up frequently throughout the night and feel poorly rested in the morning. The salivary melatonin levels also declined at night due to progressive exposure to artificial light. **Conclusion:** Through our research, we have obtained data that strongly suggest that light pollution is adversely affecting public health, causing them to experience sleep loss, visual fatigue, weariness, anxiety, and depression.

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1. Introduction

Humans evolved to the rhythms of the natural light-dark cycle of day and night called circadian rhythm, our biological clock highly involved in sleep-wake pattern and other bodily functions. These processes include brain wave patterns, hormone production (melatonin), cell regulation and other biologic activities. Disruption of these rhythms can result in insomnia, depression, cancer, and cardiovascular disease. Melatonin, a naturally occurring hormone synthesized from the pineal gland and regulated by the circadian pacemaker located in the suprachiasmatic nuclei of hypothalamus. This hormone is released by darkness and inhibited by light, and is known for helping to regulate the body's biologic clock¹.

Until the invention of electric light bulbs, people relied on the sun for the majority of their light and used only natural sources like candles, campfires and lanterns after dark.

Light is important for human to function properly. Without lights, moving and doing things will be difficult. With the dawn of modern electricity and technology, we suddenly had the ability to stay up with lights on for many hours after sunset. With computers, TVs, tablets and phones, this use has extended even more. Today a large portion of the world's population using different lights like LED lights, CFL Bulbs, halogen, neon and fluorescent bulbs as their primary light source. It is well established that humans and other biological entities are sensitive to light to various degrees, and that normal physiological processes can be influenced by light from artificial sources. As per research studies, It is now accepted that artificial night-time lighting has various effects on humans and that exposure to optical radiation affects human physiology and behavior, both directly and indirectly. This can be termed as Light pollution which has environmental consequences for the planet, as well as health consequences for humans. The use of artificial light sources disturbs the normal conditions of light at day and darkness at night and has the potential to disturb circadian rhythms⁶.

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Some Research studies showed that certain health problems can be caused by a long term suppression of our naturally and nightly occurring hormone melatonin. It regulates our circadian sleep/wake cycles and other hormonal glands i.e., help the functioning of the thyroid, pancreas, ovaries, testes & adrenal glands and offer us antioxidant protections. While there are different factors that can prevent the pineal gland from making melatonin, such as its calcification due to old age, this study particularly focused on light pollution effect on the gland at night. It also noticed that exposure to bright nocturnal light decreases the human body's production of melatonin. In the present study we focused on the hazardous effects of led bulbs and light pollution on human life and its consequences on sleep².

MATERIALS AND METHODS

Three hundred participants including males and females were voluntarily participated in this study. All the participants were interviewed for the duration of sleep at night and average duration of sleep per week since last six months was determined. Normal sleep duration is of seven hours per night and duration less than this was labeled as inadequate sleep. Ethical clearance was obtained from the Ethical Committee through the institution before the study. After getting the consent from the volunteers, all of them have experienced two test conditions:

1) A Sleep questionnaire regarding light pollution will be handed out to the participants and the completed questionnaires will be collected. This sleep questionnaire comprises the following questions which were prepared based on standard sleep questionnaires like Epworth Sleepiness Scale⁴

- 1 What time did you get into bed?
- 2. What time did you go to sleep?
- 3. How long did it take you fall asleep?
- 4. How many times did you wake up, not counting your final awakening?
- 5. In total, how long did these awakenings last?
- 6. What time was your final awakening?
- 7. What time did you get out of bed for the day?
- 8. How would you rate the quality of your sleep? Very poor/Poor/Fair/Good/Very good/
- 9. How much time in total have you been in artificial light?•

10. How much time in total have you been in artificial light prior to your bedtime?

- 11. How much time in total have you been watching TV?
- 12. How much time in total have you been working in front of computers?
- 13. How much time in total have you been exposed to night time light?

2) Estimation of Salivary Melatonin levels²:

In humans, nocturnally peaking high-amplitude oscillations of melatonin in plasma are paralleled by corresponding variations in saliva. Although plasma levels are generally about ten times higher than those found in saliva, determination of salivary melatonin can be advantageous, especially when it is preferred to avoid invasive procedures. The primary melatonin metabolite in the urine, 6-sulfatoxymelatonin, also oscillates consistently with melatonin concentration in urine, plasma, and saliva. Melatonin levels in human plasma usually begin to increase between 18:00 and 20:00 h, and peak between midnight and 05:00 h, being followed by a rapid decrease. So, measurement of melatonin in saliva is a non-invasive,

stress-free and ethically approved. Saliva samples were collected from subjects at 23:00, before starting computer tasks, and again at midnight and 01:00 while performing computer tasks under all three experimental conditions.

RESULTS:

	Day time	Night hours without any exposure to light	Night hours with exposure to light
Salivary Melatonin levels	2.457 ± 0.617 pg/mL	29.600 ± 18.231 pg/mL	14.752 ± 6.317 pg/mL

Comparison of salivary melatonin levels during the daytime and night. The salivary melatonin level at night (29.600 ± 18.231 pg/mL) was significantly higher than that during the daytime (2.457 ± 0.617 pg/mL). Particularly melatonin levels are low in persons who exposes to light during night when compared to persons who don't exposes to light during night.

Example of Epworth Sleepiness Scale scoring

The Epworth Sleepiness Scale
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Situation	Chance of Dozing
Sitting and reading	
Watching TV	
Sitting inactive in a public place (e.g. a theatre or a meeting)	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after a lunch without alcohol	
In a car, while stopped for a few minutes in traffic	

Result	What your ESS result indicates
Less than 10	You are most likely getting enough sleep However, if you have noticed a change in your normal sleep routine, you may want to discuss this with your doctor.
10 - 16	Your may be suffering from excessive daytime sleepiness You should see your Doctor to determine the cause of your sleepiness and possible treatment. Your Doctor may refer you to Sleep Services Australia for a home-based sleep study to assist in your diagnosis.
16+	You are dangerously sleepy It is imperative that you see your Doctor to determine the cause of your sleepiness, and to investigate treatment as soon as possible.

	No of hours slept	ESS score (Epworth sleep scale) score	Melatonin levels
People living in area of strong outdoor night time lighting or experimental blue light setup	4 to 5	20 - 24	14.752 ± 6.317 pg/mL
People in areas with less intense nighttime lights or experimental dark control setup	7 to 8	10 - 16	21.632 ± 10.231 pg/mL
People working more than 8hrs with computers particularly during night time	5 to 6	18 - 20	18.163 ± 8.317 pg/mL
People with normal sleeping habits	8 to 9	0 - 10	29.600 ± 18.231 pg/mL

DISCUSSION:

The physiological effects of light at night and sleep disruption have been 'proven' in the sense that there is general acceptance in the scientific community of its truth. What has not been 'proven' is that electric light-at-night causally increases risk of cancer, obesity, diabetes, and/or depression," Stevens and his co-author wrote in their recent paper⁵.

Sleep is highly underrated. It is one of the "pillars" of optimal health and as important as diet and exercise. Poor sleep is linked to heart disease, type 2 diabetes and depression. It is also one of the strongest risk factors for obesity. In the current generation the problem is that humans are sleeping much less than they did in the past. But that's not the end of it, unfortunately the quality of our sleep has suffered as well. It turns out that perhaps the single biggest contributor to our collective sleep problems is the use of artificial lighting and electronics at night. These devices emit light of a blue wavelength, which tricks our brains into thinking that it is daytime. Numerous studies suggest that blue light in the evening disrupts the brain's natural sleep-wake cycles, which are crucial for optimal function of the body. Fortunately, this problem has a simple solution and there are a few actionable steps we can take to get rid of that blue light in the evening, potentially improving our health at the same time⁶.

Our bodies have an internal "clock" that is situated in the brain. This clock regulates our circadian rhythm, the 24-hour biological cycle that influences many internal functions. Most importantly, it determines when our bodies are primed to stay awake and be productive, and when we feel tired and want to go to sleep. The circadian rhythm isn't 100% accurate. Sometimes it is a bit longer than 24 hours, sometimes a bit shorter. For this reason, it needs signals from the external environment in order to adjust itself. The most important signals that adjust this internal clock are daylight and darkness. This actually makes perfect sense throughout evolution, brightness meant that it was daytime and that we should be awake and get stuff done, while darkness meant that it was time to sleep and recover. But not all light is equal, it is primarily light of a blue wavelength (blue light) that stimulates sensors in the eye to send signals to the brain's internal clock. Keep in mind that sunlight and white light contain a mixture of various wavelengths. There is a lot of blue light within. Getting blue light (especially from the sun) in the daytime is very important. It helps us to

stay alert, while improving performance and mood. There has even been some success using blue light therapy devices to treat depression, and blue light bulbs in an office can reduce fatigue and improve the mood, performance and sleep of workers⁴.

But even though blue light is incredibly beneficial during the day, it can be a complete disaster if we are exposed to it in the evening. The problem is that modern light bulbs and electronic devices (especially computer monitors), also produce large amounts of blue light and “trick” our brains into thinking that it is daytime. When it gets dark in the evening, a part of the brain called the pineal gland secretes the hormone melatonin, which signals to our bodies and brains that it is time to get tired and go to sleep.

Blue light, whether from the sun or a laptop, is very effective at inhibiting melatonin production. This means that our bodies don't get the proper signal that it's time to go to sleep, reducing both the quantity and quality of our sleep³.

Studies have linked melatonin suppression in the evening to various health problems, including metabolic syndrome, obesity and cancer, as well as mental disorders like depression. Many have speculated that melatonin-disrupting blue light may be one of the key drivers behind obesity and many of the chronic diseases that are so common today. In our study, melatonin concentrations after in persons exposure to the blue-light experimental condition were significantly reduced compared to the dark control and to the computer monitor only conditions. Although not statistically significant, the mean melatonin concentration after exposure to the computer monitor only was reduced slightly relative to the dark control condition².

CONCLUSION:

Participants with strong outdoor lighting were more likely to have less sleep per night compared to people in areas with less intense nighttime lights. Urban dwellers were also more likely to suffer from poor sleep quality and quantity compared to people living in areas with less harsh nighttime lighting. Most of the urban dwellers are not satisfied with the quality or quantity of their sleep. Participants who were exposed to more nighttime light have higher chances of reporting fatigue compared to the other group. On average, they also slept less per night (402 minutes) compared to the other group (412 minutes).

People exposed to harsher light sources have higher chances of waking up confused in the middle of the night compared to people exposed to less light. They are also more likely to suffer from impaired functioning and extreme drowsiness. The easiest and most effective way to avoid blue light in the evening is to use amber-colored glasses. These glasses effectively block all blue light, so your brain doesn't get the signal that it is supposed to stay awake. If you don't want to use these glasses every night, then there are a few other ways to reduce blue light exposure in the evening. One popular way is to install a program called Flux on your computer⁴. This program automatically adjusts the color and brightness of your screen based on your time zone. There are a few other things you may want to consider:

- Limit or avoid TV, computer, phone, etc after dark
- If that isn't possible or plausible, use orange sunglasses to help greatly reduce the blue light.
- Turn off all lights in your home 1-2 hours before bedtime.
- Get a red or orange reading lamp, which doesn't emit blue light. Candlelight works well too.
- Keep your bedroom completely dark (highly recommended), or use a sleep mask.

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CONFLICTS OF INTEREST: Nil

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