The effect of self-luminous electronic displays on melatonin

by

Brittany Marie Wood

A Thesis Submitted to the Graduate
Faculty of Rensselaer Polytechnic Institute
in Partial Fulfillment of the
Requirements for the degree of
MASTER OF SCIENCE
Major Subject: Lighting

Approved:

_____
Mariana Figueiro, PhD, Thesis Adviser

_____
Mark S. Rea, PhD, Committee Member

_____
Russ Leslie, M. Arch, Committee Member

Rensselaer Polytechnic Institute
Troy, New York
August 2012
(For Graduation December 2012)

ABSTRACT

Circadian rhythms are biological processes that occur cyclically over a 24-hour period, an example being the sleep/wake cycle. Ideally, the sleep/wake cycle is synchronized to the naturally occurring light/dark pattern created by the rising and setting of the sun. If synchronized, individuals are awake during periods of light and asleep during periods of dark. However, due to various social and economic pressures, individuals are required to be awake during times when they would normally be sleeping. Another trend on the rise is the widespread use of self-luminous electronic devices such as computer displays, televisions, and tablet devices. These devices are used throughout the day, including the nighttime just before bed. These displays are commonly lit with light-emitting diodes (LEDs) that emit light at short-wavelengths. Melatonin, a hormone produced at night under conditions of darkness, can be suppressed when exposure to short-wavelength light occurs. Disruption of circadian rhythms has been associated with health maladies such as obesity and diabetes. Two experiments were conducted to gain a better understanding of the effect of light from self-luminous displays, more specifically light from a tablet device and a television, on melatonin levels in the early part of the night. The impact of the light from these displays on performance, subjective sleepiness, and display preference was also assessed.

Thirteen subjects were exposed to light from a self-luminous tablet device (the Apple iPad). Subjects were exposed to three experimental conditions over three nights, each one-week apart. The conditions were 1) tablet-only set to the highest brightness level, 2) tablet viewed through orange-tinted safety glasses (dark control; optical radiation < 525-nm ≈ 0), and 3) tablet viewed through clear safety glassed equipped with blue LEDs, thus providing 40 lux of 470-nm light at the cornea. For the tablet plus blue LED condition, 1-hr and 2-hrs of exposure resulted in suppression values statistically greater than zero. Suppression after 1-hr exposure to the tablet-only was not statistically greater than zero, but did reach significance after 2-hrs of exposure. Predictions made using the phototransduction model and data from the Dimesimeter were close to the measured melatonin suppression values after one hour. Performance decreased (increased reaction time) over the course of the night for each of the three conditions.

During another experiment, sixteen subjects were exposed to light from a television. Eight subjects viewed the display from 6 ft, and eight viewed the display from 9 ft. Subjects were exposed to four lighting conditions over four nights, each one-week apart. The four lighting conditions consisted of three different correlated color temperature (CCT) settings (12,000 K, 6500 K, and 2700 K) and a dark control (12,000 K plus orange-tinted safety glasses). It was predicted, using the phototransduction model and Dimesimeter data, that the melatonin suppression resulting from the TV exposure would be low. Statistically significant suppression was not observed for any of the lighting conditions at either viewing distance, and KSS responses increased over the course of the night for all four conditions. Subjective ratings of picture quality and color were significantly lower when the TV was viewed through the orange-tinted glasses.

The results from these studies suggest that, depending on the duration of exposure, light provided by a self-luminous display may suppress melatonin. Recording actual light exposures and using the model of phototransduction, predictions can be made regarding the impact of these displays. Manufacturers can use this information to produce displays that minimize the risk of nocturnal melatonin suppression.