The impact of 470-nm light on acute nocturnal melatonin suppression

by

Natalia Z. Lesniak

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, Ph.D., Thesis Adviser

_____

Mark Rea, Ph.D., Committee Member

_____

Andrew Bierman, M.S., Committee Member

Rensselaer Polytechnic Institute
Troy, New York

August, 2011
(Graduation December, 2011)

ABSTRACT

A model for human circadian phototransduction, published by Rea et al. (2005), incorporates the known neuroanatomy of the human circadian system. This mathematical model is a work in progress and is based on existing empirical studies. As more studies are performed, model calculations will be refined and adjusted to reflect the additional data. Currently the model has greater relative uncertainty for lower light levels, near the threshold response. The current study is an extension of the work begun by Figueiro et al. (2009), which investigated the impact of two corneal irradiances (11 and 74 μW/cm²) of 470-nm light. The overall purpose of this thesis study was to develop a complete data set for one peak wavelength with respect to irradiance and exposure duration. The experiment described in this thesis was conducted at the Lighting Research Center in Troy, NY over the course of five weeks. The study investigated the impact of four corneal irradiances (0.7, 2, 6, and 20 μW/cm²) of 470-nm light and one dark control condition on acute nocturnal melatonin suppression over the course of 90-minutes. Each week participants were exposed to one of the conditions for 90-minutes. The resulting data provide a more detailed understanding of melatonin suppression in response to 470-nm light. The experiment also provided data with which to check model predictions. In response to 0.7 and 2 μW/cm² mean relative melatonin concentrations were lower than in the dark condition, over the course of 90 minutes. The melatonin concentrations from the two lowest irradiance conditions resulted in higher concentrations after 90 minutes of exposure, compared to mean relative melatonin concentrations just prior to light exposure. Melatonin concentrations resulting from the higher irradiance conditions (6, 11, 20, and 74 μW/cm²) were lower after 90 minutes of exposure, compared to mean relative melatonin concentrations just prior to light exposure. The threshold for acute nocturnal melatonin suppression was revealed to be between 0.7 and 2 μW/cm² for a continuous 90-minute exposure. Significant melatonin suppression was found for: 11 μW/cm² for 20 and 60-minute exposure durations, for 20 μW/cm² for 30, 60, and 90-minute exposure durations and 74 μW/cm² for 60, 75, and 90-minute exposure durations. Calculated suppression for 60-minute exposures and 2005 model estimated suppression were compared through a correlation, which resulted in a slope of 0.81 and an R^2 value of 0.78. Since the completion of the experiment and the initial comparison, several

adjustments were made to the circadian phototransduction model with regard to lens transmission, threshold, and the spectral opponent response. A second correlation was completed between calculated suppression and new 2011 model estimated suppression resulting in a slope of 0.96 and an R^2 value of 0.75. The second correlation demonstrated an improvement in model estimates for 470-nm light.