**The Effect of Blue Light on Circadian Rhythm and Sleep**

**Introduction:** Light is well known to stimulate sight and make things visible. However, recent studies have shown that light plays a larger biological role for humans and can help regulate our sleep/wake cycle, even impacting sleep stages and memory processing (Chang et al, 2015). In many studies, results showed that daylight can improve human performance in schools and office buildings (Figueiro et al, 2011). When people were exposed to daylight in the morning they went to bed early, yet when exposed to the same type of light in the evening they had sleep disruptions. (Hanifin & Brainard, 2007) Blue light is part of the visible light spectrum and includes the shorter wavelengths of light in the 380-500 nm range. Blue light in the 415-455 nm range can cause damage to the retina (Arnault et al, 2013) and can cause over-focusing problems at near and blur at distance for students exposed to the 417-430 nm wavelengths. (Graef & Schaeffel, 2012) Too much exposure to blue light has also been shown to cause types of cancer and macular degeneration. Computers, LED lights, and compact fluorescent lights (CFLs) all emit significant amounts of blue light. CFLs contain about 25% blue light while LEDs contain 35% (Smick et al, 2013). Recently, we learned that we had new LED lighting installed in our classrooms and science labs which caused headaches and sleeping disruptions among many students, inspiring us to research the lighting change further.

It is estimated that by 2020, 90% of all our light sources will be LED lighting which means that our exposure to blue light is only increasing (Melton, 2014). Studies found that our eyes have receptors known as ipRGC’s (intrinsically photosensitive retinal ganglion cells). These nerves are a type of photoreceptor, which means they are sensitive to light, and they are most sensitive to the blue wavelengths of light in the 446-484 nm range. (Hanifin & Brainard, 2007) These nerves are triggered by light from a person’s surroundings and send it to the part of the brain called the suprachiasmatic nucleus, which controls photobiological responses (biological processes that depend on light, such as the circadian rhythm). (Hanifin & Brainard, 2007) This is how blue light, with its shorter
wavelengths, affects sleep. Blue light is helpful in the morning to signal your brain that it is time to wake up, however it interferes with the circadian rhythm when you are exposed to it at night time by decreasing melatonin production, negatively affecting sleep quantity. (Hanifin & Brainard, 2007)

Through this project, we would like to see what the optimum amount of blue light exposure is for middle school students, so that it does not negatively impact their circadian rhythms.

**Problem Question:** What is the ideal amount of blue light exposure for teenagers, so that it resets the circadian rhythm but does not negatively affect sleep quantity via overexposure, and how can this be implemented in classrooms?

**Hypothesis:** Based on information about ipRGC’s and their role in regulating the circadian rhythm, it is hypothesized that a fixed amount of morning exposure to LED lighting will help students to reset their circadian rhythm while not decreasing sleep quantity.

**Methodology:** The experiment is designed to measure sleep obtained by students who are exposed to different amounts of blue light during the day. Sleep quantity will be measured using Charge HR Fitbits and the Fitbit smart phone app. Charge HR Fitbits are devices to be worn on the wrist. They are mainly used to track heart rate, thus they are able to detect when a person’s heart rate slows and they fall asleep. The hours of sleep a person gets then shows up on the smartphone app. (Kelly et al, 2012)

To ensure that students will not be exposed to any extra blue light past their allotted hours, all students will subsequently be sent to a building where no artificial blue light is present after their experiment session is over. No computers will be used by students during this experiment, as they emit a significant amount of blue light and could impact the validity of the results. By measuring the different amount of sleep students experience, our goal is to determine the ideal amount of classroom blue light exposure for middle schoolers.
**Procedure:** Distribute 40 Fitbits among 40 students (one Fitbit per student). Divide students into 4 groups of 10 (Groups A, B, C, and D). Connect the Fitbits for each group to a smartphone devoted to collecting their group data (4 smartphones required). Send each group into a designated classroom for classroom instruction (these rooms will contain LED lighting). Group A will be exposed to LED lighting for 2 hours, Group B for 4 hours, Group C for 6 hours, and Group D for 8 hours. At the conclusion of their allotted LED light exposure, students will be sent to building free of artificial blue light for their classes for the remainder of the 8-hour school day. (Group D will not have additional class time in the second building). All students will spend the night in the building environment, exposed to no artificial blue light. Once everybody is awake the next morning, check the Fitbit apps on Smart Phones A, B, C, and D.

**Real World Application/ Next Steps:** This research’s conclusions on the optimum amount of blue light exposure for students should be shared with school administrators so that schools can take measures toward protecting student health by installing appropriate lighting in their classrooms. Some solutions (that would need to be designed by engineers) could be classroom light filters that would stop blue light from coming through the LED lights after the ideal amount of exposure by use of an automatic timer system. Or, LED lights could only be used for the recommended exposure amount and then alternate, blue-light free light sources could be used for the remainder of the day. Perhaps even eyewear that blocks blue light could be used by students after the recommended blue light exposure amount. This can help schools and workplaces still be energy efficient because they can have LEDs but at the same time prevent the negatives impacts from blue light overexposure.


