Scientists have long known the strategic use of bright light can change a person’s circadian rhythm (i.e., “biological clock”). But is it possible that only certain wavelengths within light are responsible for the circadian rhythm shifting effects of light? In recent years, scientists have examined this question with some interesting findings.

In 1980, Alfred Lewy and colleagues discovered that light with an intensity of 2500 lux could immediately stop melatonin production in humans. Before this discovery, scientists had noted that strong intensities of light could suppress melatonin production in animals, but humans appeared to lack this response. Lewy’s finding stimulated interest in strategically using strong light intensities to temporarily stop melatonin production. Bright light therapy has been an outgrowth of this interest and is used to shift the sleep/wake phases (and thereby improve sleep) in people who have seasonal affective disorder, delayed sleep phase syndrome, jet lag, or a free-running rhythm.

In bright light therapy, a special lamp produces the high-intensity light that can range from 2000 lux to 10,000 lux. (The light intensity, measured in units called “lux,” of a bright sunny day is approximately 500 lux). A person sits in front of the light for 30–90 minutes either soon before going to bed or soon after awakening. A person sits about 2 feet from the bright light lamp, but does not look directly into the light. The greater the light intensity, the less time a person needs to sit in front of the lamp for an effect. Exposure to morning bright light treatment normally shifts a person’s sleep and wake phases to an earlier time the following day. Exposure to evening bright light shifts a person’s sleep and wake phases to a later time the following day. Once the person’s sleep and wake phases have shifted to a desired time, the person must maintain the new sleep/wake schedule with bright light exposure ideally taking place at the same time every day.

Studies that investigated the physiological effect of different colors of light on humans indicated that certain colors of light could impact certain physiological processes. For example, one study indicated that red light could prolong estrus in rats and blue and green light could inhibit melatonin production in albino rats and hamsters. On similarly examining the impact of specific colors of light on humans, scientists found that light at a wavelength of 509 nm (i.e., green light) appeared to inhibit melatonin production in humans.

The human eye perceives wavelengths of 400 to 700 nanometers (nm). This range is called “visible light.” Any wavelength outside this range can not be perceived (e.g., X-rays [which range from 1/1000 of a nanometer to 10 nm] and infrared waves [which range from 1 micrometer to 1 millimeter]). When all wavelengths are present in light, the light appears white. If the wavelengths are separated (for example, through a prism or in a rainbow), they can be perceived as colors (i.e., red, orange, yellow, green, indigo, and violet). The wavelength range of each color is (from the longest to shortest length): red, 620–750 nm; orange, 590–620 nm; yellow, 570–590 nm; green, 495–570 nm; blue, 450–495 nm; indigo, 420–450 nm; and violet, 380–420 nm. (Some charts do not include the indigo as a color since people usually can not distinguish indigo from blue and violet, thereby making the range for violet 380–450 nm.)

When light enters the eye, photons (i.e., light particles) strike and thereby stimulate retinal cells such as cones, rods, and retinal ganglion cells. Cones play a role in color perception. Rods play a role in the perception of motion and vision in dim light settings. Retinal ganglion cells receive signals from photoreceptors (e.g., cones and rods) and then transmit image-forming and nonimage-forming information from the retina to several regions of the brain. The axons of retinal ganglion cells extend from the retina through the optic nerve and to the hypothalamus (i.e., the retinohypothalamic tract), the lateral geniculate nucleus (located in the thalamus), and the suprachiasmatic nucleus (SCN, which plays a role in circadian rhythmicity).

A small group of retinal ganglion cells, called intrinsic photosensitive retinal ganglion cells, are nonimage-forming photoreceptors: they respond to light but do not play a role in the perception of images. Examples of nonimage-forming effects of light are photoentrainment (i.e., the synchronization of endogenous circadian clocks to the external cue of light/dark cycles), changes in pupil size in response to light intensity (i.e., pupillary light reflex), pineal melatonin production, and sleep propensity (i.e., the time during which the body is most inclined to rest).

Intrinsic photosensitive retinal ganglion cells contain melanopsin, a light-sensitive protein (i.e., photopigment). Melanopsin photoreceptors have their peak absorption of light that has a wavelength of approximately 488 nm (i.e., blue light). Some research indicates that blue light, which has a short wavelength, seems to have a greater alerting effect than red light, which has a long wavelength. Therefore, melatonin production is more reduced with blue light than with red light.
Mirjam Münch\textsuperscript{11} and colleagues investigated the impact of light wavelength on sleep stages. In their study, they exposed study participants to blue (460 nm) or green (550 nm) light for 2 hours in the evening. Münch hypothesized that, since retinal ganglion cells are very sensitive to short wavelength light (i.e., blue or green light), as evidenced by the reduction of melatonin production, the impact of these wavelengths on sleep would be the same as using high-intensity (i.e., bright) light. Blue light at 460 nm slightly reduced slow wave activity (0.75–4.5 cycles/second [Hertz (Hz)]) during the first sleep cycle, significantly increased slow wave activity during the third sleep cycle, and shortened rapid eye movement (REM) sleep duration during the first and third sleep cycles. Münch concluded that blue light treatment may cause a circadian phase delay and/or a stronger alerting effect.

Treating circadian rhythm disorders by using certain wavelengths may prove to be simpler than using bright light treatment. In a study by Mariana Figueiro\textsuperscript{12} and colleagues, specialized goggles that emitted blue light wavelength (470 nm) to an individual’s eyes were found to stimulate the circadian system of older adults, as reflected by the inhibition of melatonin production. The individuals wore the goggles for 90 minutes and reported being able to watch a movie comfortably while wearing them. The goggles are experimental and had been created for this study. If they are developed for treatment, goggles will allow a person more mobility to perform routine tasks while undergoing treatment. By contrast, bright light therapy requires a person to sit in front of the lamp for the duration of each treatment.

Using specific wavelengths to treat circadian rhythm disorders may someday be perfected. However, even with apparently proper treatment, other factors such as genetic factors may negatively impact treatment efforts. Some research indicates that genetic factors may play a role in the response to light intensity. For example, Sarah Chellappa\textsuperscript{13} and colleagues recently investigated the impact of red-enhanced fluorescent light and blue-enhanced fluorescent light on two forms (i.e., alleles) of the Period 3 gene: (\textit{PER3}(4/4) and \textit{PER5}(5/5)). The Period 3 gene plays a role in circadian rhythmicity. The study participants were exposed for two hours to the wavelengths. Chellappa found that blue-enhanced light significantly suppressed the normal evening rise in the melatonin levels in people with the \textit{PER3}(5/5) allele, but not in people with the \textit{PER3}(4/4) allele. This indicates that genetic factors may impact a person’s sensitivity to blue light.

Researchers have yet to determine the ability of different wavelengths to induce phase shifts, entrain the circadian system, improve subjective daytime sleepiness, and improve nighttime sleep quality. Once this is determined, strategic use of specific wavelengths may be used to restore circadian rhythmicity in people with a free-running rhythm or shift sleep/wake phases in people with delayed or advanced sleep phase syndrome or in people with jet lag. Another factor that needs to be investigated is determining the best candidate for such treatment. For example, scientists currently do not know the extent that specific wavelengths of light will improve the sleep of people with Alzheimer’s disease or people with a brain injury. In the Figueiro study,\textsuperscript{12} the researchers noted that the intensity and wavelength of light did not appear to cause any harm to the eyes of the study participants. Future studies may determine whether people with certain eye diseases should not be exposed to specific wavelengths.

The typical incandescent light bulb emits most of its light from the long wavelength (i.e., red) portion of the spectrum and the typical fluorescent light bulb emits most of its light from the middle wavelength (i.e., yellow to green) portion of the spectrum. To mimic sunlight, bright light bulbs emit most of the wavelengths found in sunlight (i.e., they are full spectrum, with the exception of ultraviolet light to reduce risk of skin cancer). In the future, phototherapy (i.e., “light therapy”) may include the use of red-enhanced light or blue-enhanced light (i.e., light that includes more wavelengths in the red or blue range) or the use of specific wavelengths to treat sleep disorders.

\textbf{REFERENCES:}


Get your Polysomnography Certificate through distance education at any time.

Study Polysomnography at Thompson Rivers University, Open Learning and enjoy the flexibility of online delivery.

Begin the program, which includes three online theory courses and one two-week clinical practicum, when the time is right for you and receive leading-edge information in sleep medicine.

Thompson Rivers University is a BRPT STAR Focused Education provider.