SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

Demonstrate how three metrics (circadian action factor, circadian stimulus, and equivalent melanopic lux) can be used when simulating the effects of light within built environments.

Application of different circadian lighting metrics in a health residence

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Key Concepts/Context

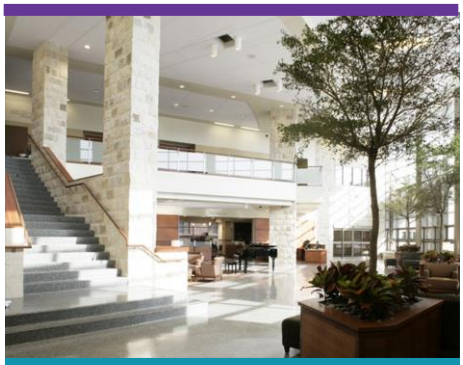
Previous studies have established that indoor illuminance must reach certain levels for proper visual performance, and should also work to enhance spatial perception, security, and well-being. Insufficient indoor lighting can adversely influence patient health outcomes, particularly patient circadian rhythms. The circadian rhythms of elderly patient populations may be especially sensitive to illuminance levels. This study suggests that designers could make more informed decisions regarding natural and artificial lighting design by consulting different circadian assessment metrics.

Methods

The methodology of this study is divided into two parts: first, the authors define their three primary metrics through measurements and simulations, and second, the authors perform a case study in an assisted living healthcare residence to evaluate different circadian effects within both a gymnasium and a patient room, where they also experiment with potential lighting improvements.

The authors employed three different metrics (all of which were described and tested in previous studies):

- Circadian action factor (a_{cv}) – an indicator of the effect a given light source has on the circadian system.
- Circadian stimulus (CS) – the authors use this term interchangeably with circadian light (CL) to indicate any effective photic stimulus for the circadian system as estimated by intense nocturnal melatonin suppression.
- Equivalent melanopic lux (EML) – used as part of a rating system which identifies the parameters of well-being for architectural designs in terms of natural and artificial light. The EML is measured vertically from the height



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of the observer's eyes while factoring in illuminance values and the weight of the light source spectrum.

A Spectrascan PR-650 spectrometer radio from Photo Research was used during the analysis process in both the gymnasium and patient room. The analysis process involved simulations of both electric and natural lighting.

The gymnasium measured 13.5 meters (m) wide by 7.9 m deep by 3 m high. Horizontal windows of different sizes were located on the gym's eastern side. The patient room measured 5.5 m wide by 3.8 m deep by 2.7 m high, with vertical windows (0.9 m wide by 2.4 m high) on the eastern side. In both spaces, natural light was simulated using a CIE D65 Overcast Daylight.

Findings

With regard to daylighting, part of the goal of the simulation and case study phases was to reach or exceed certain thresholds of all three metrics; designing environments which met or exceeded the benchmarks of these metrics that were established through previous studies would, in theory, more effectively promote melatonin suppression during daylight hours. Since these benchmarks were exceeded during the experiment, the authors suggest that their recommendations for lighting and design are worth consideration. The simulation and case study phases of the study showed that the colors of the interior walls, as well as the spectral interreflections inside of the rooms, had an effect on all three metrics. A particularly noticeable impact was seen in illuminance levels around the average eye level of patients.

The electrical lighting involved in this study featured a correlated color temperature (CCT) of 6,500 K, because previous studies showed that this led to an increase in a_{cv} and CS; this was verified through the present study. Additionally, it was found that lamps with a spectral power distribution (SPD) lower than 3,000 K decreased the impact of circadian stimulus. Similar to natural lighting, wall color influences the amplification or reduction of $a_{cv;}$ however, this study found that wall colors affected by electrical light did not influence the CS metric.

Limitations

The authors acknowledge that their simulations of natural lighting did not incorporate various fluctuations in weather patterns; future studies might incorporate more variations in daylighting levels. This study did not involve any living participants or observations on sleep cycles over time; therefore the conclusions are theoretical. This study took place at a single location; therefore its results may not be applicable to healthcare spaces in different locations.

Design Implications

The results of this study indicate that interior wall colors can have a notable impact on circadian rhythms due to the reflection of light; in certain spaces, painting the ceiling blue may help improve certain circadian metrics.