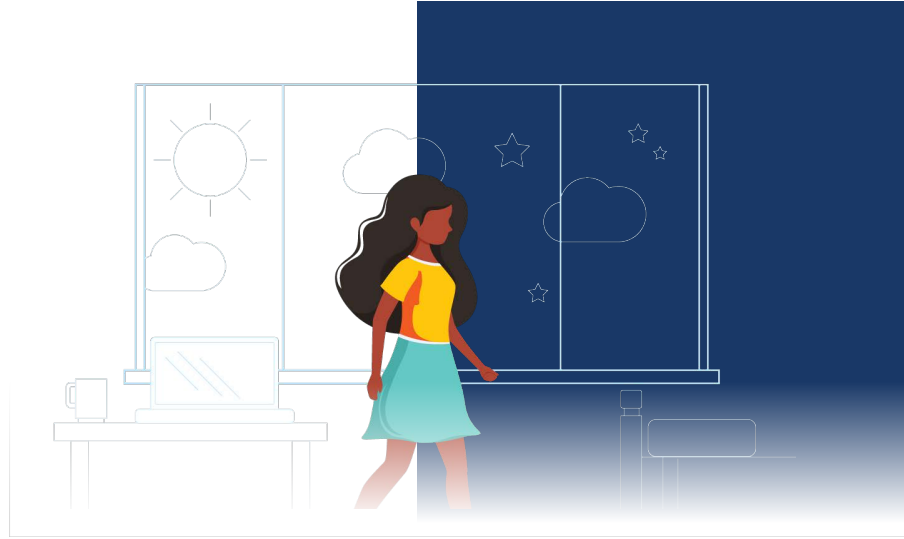


# Brighter Days Make For Better Nights

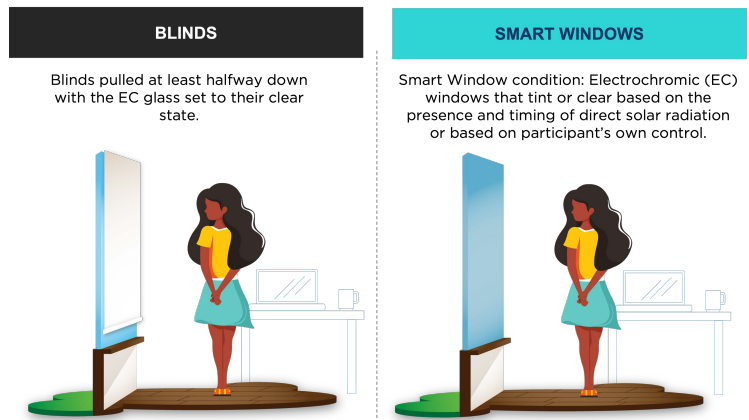


## Executive Summary

Access to daylight at home is not just a desirable amenity but is a fundamental physiological requirement. We are an outdoor species, having evolved in the natural world with a 12-month cycle of seasons and a 24-hour cycle of day and night. Circadian systems have evolved in nearly all species to regulate physiology and behavior in response to daily variations in daylight. The amount of daylight we are exposed to, or the lack thereof, has a significant influence on the quality of our sleep, mood, and health.

The REVOLV study, conducted by the Icahn School of Medicine, Mount Sinai, sought to study the impact of daylight on physiological, behavioral, and subjective measures of health in a real-world environment. Understanding these dynamics in practice are key to designing buildings that are optimized for human health and well-being.

## Study Design



20 residents living in the EXO Apartments in Reston, Virginia, were exposed to two conditions for a period of 1 week each in their apartment. Participants' sleep patterns were recorded using wrist-worn sleep trackers and saliva samples were collected during the evening hours to measure for levels of melatonin - the hormone that triggers sleepiness at night.

## Sleep

Participants went to sleep 22 minutes earlier and slept 16 minutes longer in the Smart Windows condition. Their sleep was also more consistent from one day to the next, a sign of good sleep hygiene. These impacts were likely driven by the improved daytime circadian-effective light levels imparted by the Smart Windows.

### SMART WINDOWS

Earlier sleep onset by 22 min

### BLINDS

Sleep debt compensation on Friday night

## Melatonin

Daylight is the main environmental cue that regulates the body's internal clock, keeping it in sync with the day/night cycle. The Smart Windows condition resulted in greater alignment of the circadian rhythm with the sun cycle, resulting in consistent timing of melatonin release (the sleep hormone).

### SMART WINDOWS

Consistent melatonin onset

### BLINDS

15 minutes delay over the course of the week



## Alertness & Mental Health

Providing optimal light indoors not only impacts sleep but also daytime energy levels and mental health. While in the Smart Windows condition, residents demonstrated a distinct cycle of high morning and daytime alertness and winding down before bed - a cycle that remained relatively consistent from the start to end of the week. Meanwhile, in the Blinds condition, they exhibited higher nighttime energy levels and lower morning vitality. Participants also reported 11% lower levels of anxiety and 9% lower stress while in the Smart Windows condition.

### SMART WINDOWS

Consistent cycle of vitality with high morning and daytime energy levels

### BLINDS

Delayed peak vitality, high nighttime energy levels and low morning vitality

# Research Methods

20 residents living in the EXO Apartments in Reston, Virginia, were exposed to two experimental conditions for a period of 1 week each in their apartment.

Throughout the entire study, participants' sleep patterns were recorded using wrist-worn sleep trackers and surveys related to physical and mental health were completed. Participants also wore a personal light monitor called a Daysimeter during the day to record their activity patterns and personal light exposures during the intervention periods.

## BLINDS

Blinds pulled at least halfway down with the EC glass set to their clear state.



## SMART WINDOWS

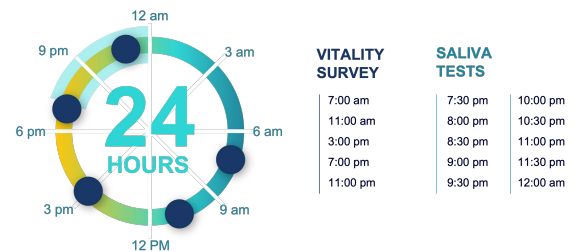
Smart Window condition: Electrochromic (EC) windows that tint or clear based on the presence and timing of direct solar radiation or based on participant's own control.



PARTICIPANTS	WEEK 1	WEEK 2	WEEK 3	WEEK 4
10	BASELINE	SMART WINDOWS	BASELINE	BLINDS
10	BASELINE	BLINDS	BASELINE	SMART WINDOWS



On the first and last days of each intervention, surveys of self-reported vitality were completed every 4 hours throughout the day. In the evening hours, participants collected 10 saliva samples under a researcher's supervision. These samples were sent to the lab at Mount Sinai to be analyzed for dim light melatonin onset, which marks the start of melatonin production in the body - the hormone that triggers sleepiness.



## The Expert



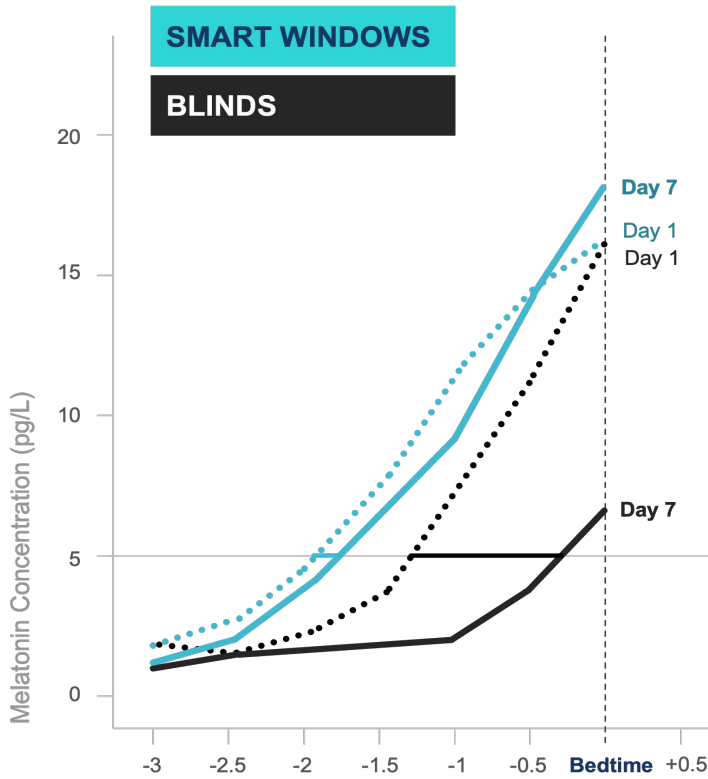
**Dr. Mariana Figueiro**

Director, Light and Health Research Center  
Icahn School of Medicine, Mount Sinai

## The Study Site



# The Results



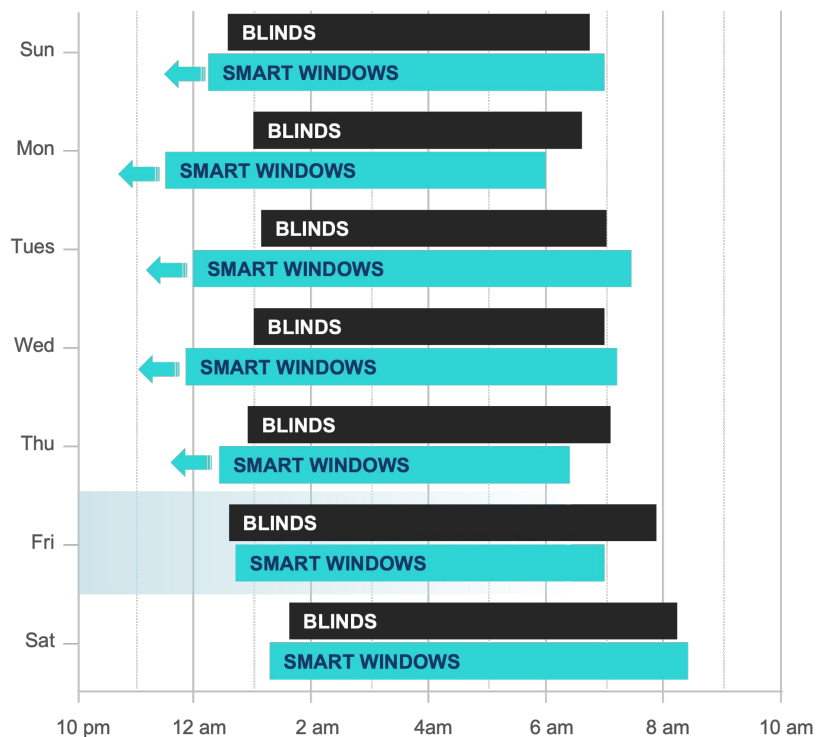
## Melatonin

Daylight is the main environmental factor that regulates the body's internal clock, keeping it in sync with the day/night cycle. The Smart Windows condition resulted greater alignment of circadian rhythms with the external sun cycle, resulting in consistent melatonin onset. In contrast, participants exhibited a 15-minute delay in melatonin onset over the course of the week in the Blinds condition.

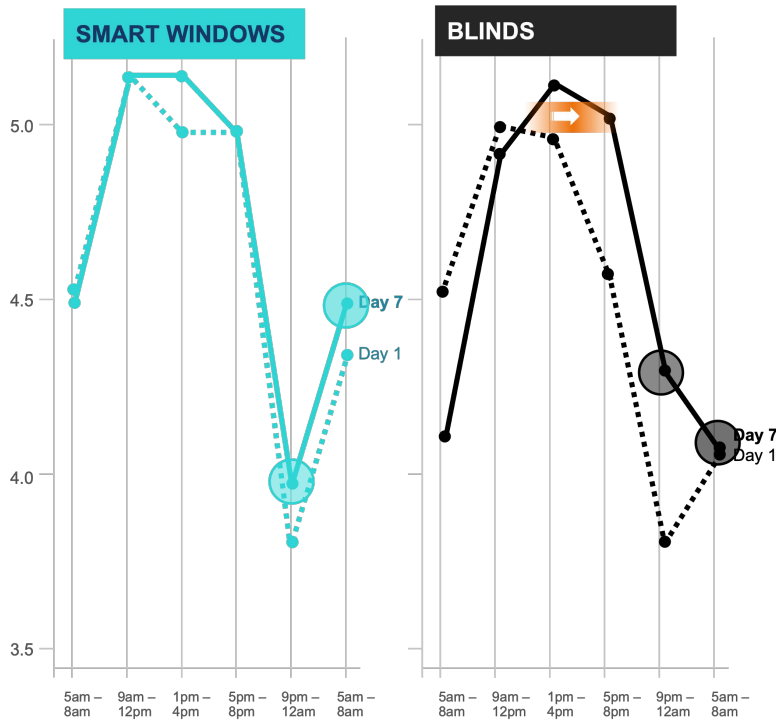


## Sleep

Participants went to sleep 22 minutes earlier, resulting in a total of 16 minutes more sleep each night, in the Smart Windows condition. Their sleep was also more consistent from one day to the next, a sign of good sleep hygiene. These impacts were likely driven by the improved daytime circadian-effective light levels imparted by the Smart Windows, supporting the existing research on the benefits of short wavelength light on human circadian rhythm entrainment and sleep quality.



## Alertness & Mental Health



Providing the optimal light conditions indoors not only impacts circadian rhythm and sleep but also impacts daytime energy levels and mental health. While in the Smart Windows condition, residents were 11% less anxious and 9% less stressed than when they were in the Blinds condition. They also demonstrated a distinct cycle of high morning and daytime vitality and low energy at night - a cycle that remained relatively consistent from the start to end of the week. Meanwhile, in the Blinds condition, they exhibited a delay in peak vitality, higher nighttime energy levels, and lower morning vitality at the end of the week compared to the start.



## Conclusions

This study highlights the importance of daylight on sleep quality and mental health, and replicates the physiological mechanism shown in previous laboratory studies in a real-world environment. Smart Windows optimize indoor daylight access and occupant health without the drawbacks of visual and thermal discomfort, energy consumption, and reliance on occupant behaviors that come with traditional façade solutions.

