Green light is effective in advancing the timing of sleep onset and increasing duration of sleep

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Abstract

We investigated the ability of green light to advance sleep onset to an earlier time and increase sleep duration. The participants (*n* = 24) were asked to nominate their current sub-optimal sleep-wake times and their preferred earlier or ideal sleep-wake times. Participants were asked to use a green light device for 50 minutes each morning for 7 days. This resulted in participants feeling sleepier in the early-evening and produced an advance of their sleep onset times. This advance in sleep onset was accompanied by an increase in sleep duration. The study suggests that green light is effective in re-timing the circadian clock of a non-clinical population and resulting in improved sleep.

Key words: green light, bright light therapy, delayed sleep phase, advanced sleep phase

INTRODUCTION

Sleeping difficulties can occur when there is a discrepancy between the timing of the circadian clock and an individual's preferred sleep period. If sleep is attempted at a circadian time that is not optimal for the major sleep episode, sleep problems such as difficulty falling asleep or early morning awakenings may occur. In an individual with a normally timed circadian rhythm the major sleep period would occur between 23.00 and 07.00 hours, with maximum circadian sleepiness at the time of the core body temperature minimum (CBT min) (between 04.00 and 05.00 hours).

The wake-up time usually occurs soon after the core body temperature begins to rise (06.00 to 07.00 hours). The period around the body temperature maximum (18.00 to 20.00 hours), termed the "wake maintenance zone" is a time when sleep initiation is inhibited.[1]

If the circadian clock becomes delayed in timing, for example from sleeping in late on a weekend, the wake maintenance zone is also delayed and may extend until midnight.[2] This can inhibit sleep onset until midnight. Problems then arise when occupational demands require early wake-up times, resulting in insufficient total sleep time and concomitant poor daytime functioning.

The study of bright light to advance the circadian clock has been widely researched at Flinders University.

The aim of the present study was to evaluate the effectiveness of bright green light administered shortly after wakening in advancing sleep onset to an earlier time. By advancing sleep onset, it was hoped that participants could move their circadian clock to an earlier time thereby increasing duration of sleep.

GREEN WAVELENGTH

Although broad-spectrum white light has typically been used for bright light therapy, researchers have recently reported that circadian rhythms are more responsive to shorter wavelength (blue to green) than longer wavelength (yellow and red) light.[3]

In their seminal research, Flinders University researchers found that blue (470nm), blue/green (497nm) and green (530nm) were the most effective wavelengths at re-timing the circadian clock.

GREEN WAVELENGTH FOR OLDER POPULATIONS

While blue to green wavelengths have been shown to be the most effective at re-timing the circadian clock in young adults, the blue/green to green wavelengths may be particularly effective in middle aged to older populations.

Our eyes have a lens that becomes cloudy and yellows as we age. This clouding allows less blue light into the eye. This may mean that devices relying on blue wavelengths, particularly those in the range of 450nm – 470nm, are sub-optimal in re-timing the circadian clock.

A recent study from the Netherlands investigated the ability of light to re-time the circadian clock in a population of 66 to 87 year olds.[4] The study found that those whom had recently undergone cataract surgery to remove the yellowed lens achieved greater melatonin suppression with light therapy, compared with those who had not. These findings support the hypothesis that green light (500nm) would be more effective in older populations, given more light will reach the eye to suppress melatonin. In the present study a 500nm (blue/green) light device was used.

GREEN LIGHT DEVICE

The portable light source used was Re-Timer which comprises four green LEDs (500nm peak wavelength with irradiance of 230uW/Cm2) attached to the lower rims of the frames. The LEDs are directed towards the eyes, approximately 20mm from the corneal surface. Users reported the device to be comfortable and convenient.

The device has been independently tested for ocular safety to the standard (CEI IEC 62471).

Picture 1: Re-Timer device utilizing 500nm wavelength

MATERIALS & METHOD

Requests were made on radio and in local newspapers for people to participate in a study to re-time their circadian clock to an earlier time. Participants registered their interest via a website. To determine baseline measures participants nominated their typical sleep-wake schedule and their preferred earlier sleep wake times. A series of exclusion questions were also asked.

314 people nominated for the trial. 82 people were randomly selected to participate. 58 were subsequently excluded due to one or more of the following reasons: incomplete sleep diaries; did not start the trial in time for completion; declined to participate mid-trial; failed to return their sleep diary; became ill with the flu and was unable to complete the study; did not use Re-Timer according to the schedule of use provided. This left a sample size of 24 (15 male; 9 female). Their ages ranged from 18 to 72 years (M = 41).

During the treatment week participants were asked to use the green light device for 50 minutes each 24-hour period for 7 days. All participants used the device in the morning shortly after waking (M = 8:42am, SD = 2.23 hours).

Wake-up times and exposure to green light were gradually advanced by an average of 8 minutes each morning, starting from each participant's usual wake-up time.

The choice of bedtime and wake up times across the week were self-selected. Participants were only requested to use the device for 50 minutes at the prescribed time. After awakening, all participants followed their usual morning routine whilst wearing the Re-Timer device. Participants recorded their sleep-wake routine during the treatment week in a sleep diary.

The study was carried out in winter with morning light levels <100lux indoors and <1000 lux outdoors.

RESULTS

Baseline data provided by participants prior to the trial showed the average sleep onset time was 1:47 am (SD = 82 minutes). The average preferred sleep onset time participants wanted to achieve was 11:00pm (SD = 56 minutes). This would be an average advance in sleep onset of 2 hours and 47 minutes, a significant change in the circadian clock.

92% (n = 22) achieved a movement towards their preferred sleep onset time, 8% did not realize any movement in their sleep onset time. An average advance of 2 hours and 30 minutes was achieved across the whole sample (n = 24). This is 90% of the target sleep time.

For green light to be considered an effective treatment option, duration of sleep should either be constant or increase as sleep onset time advances. Reduced sleep duration would only result in sleep debt.

Average sleep duration prior to study commencement was 7.1 hours (SD = 1.4 hours). On the 7th day of use, average sleep duration of participants was 7.8 hours (SD = 1.92 hours), an increase over the baseline measure by 0.7 hours (42 minutes).

To provide greater context to these results, verbal feedback was recorded and select statements provided here:

> "*I found after the 3rd night wearing it, I was able to fall asleep much quicker than I have in the past. Also, I did feel I slept a bit deeper and was more rested when I woke up the next morning, but I did still wake up once or twice through the night. Still it was considerably less than I have been experiencing before trying the Re-Timer*" – Participant 17

> "*I'm happy to say that although with a struggle here and there, I now wake up feeling refreshed and with no urge to take naps*" – Participant 5

> "*I noticed a slight difference after my first use, which kept on improving for the duration of the trial. Before the trial I was sleepy and grumpy in the mornings, hitting snooze on my alarm about ten gazillion times. This would make me in one hell of a rush getting the kids ready for school, and the stress from that would put me in a bad mood for the next few hours. One extra thing I thought you might be interested in also, is that I now remember my dreams when I wake up, which I was never able to do before the trial*" – Participant 20

DISCUSSION

In this study, a treatment protocol for advancing sleep onset to an earlier time consisting of the gradual advance of wake-up times and 50 minutes of bright green light shortly after waking was successful in advancing sleep onset as well as increasing the amount of sleep.

At the conclusion of the treatment week 92% of participants achieved their goal of shifting their sleep period more than two hours earlier. For these participants early morning use of green light resulted in feelings of sleepiness in the early evening resulting the ability to get to bed and asleep earlier and increased sleep duration.

These results indicate that green light can be an effective treatment protocol for those who want to go to sleep earlier and

sleep longer. However, whilst advancing sleep onset is achievable, this will be accompanied by earlier awaking times in some individuals although still achieving increased sleep duration. Future research would benefit from investigating the reasons for this.

Analysts whom collected data have noted that some sleep diaries appeared to contain patterns common to those of shift workers. Also, some diaries contained evidence of "afternoon naps" which is counterproductive to re-setting the circadian clock. Future research would benefit from coaching participants not to take naps during the day.

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ABOUT RE-TIME PTY LTD

Since 1987 sleep psychologists from Flinders University have studied the effect of light in re-timing the circadian clock. Their research led to the development of the world's first light device to specifically advance and delay the circadian clock.

To learn more or request units for research please contact: support@re-timer.com

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FURTHER RESEEARCH FROM THE SLEEP LABS OF FLINDERS UNIVERSITY

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