Light Treatment for Sleep Disorders: Consensus Report IV. Sleep Phase and Duration Disturbances

J Biol Rhythms

Terman M, Lewy AJ, Dijk DJ, Boulos Z,
Eastman CI, Campbell SS

J Biol Rhythms 1995 Jun;10(2):135-47 Related Articles, Books, LinkOut

Light treatment for sleep disorders: consensus report. IV. Sleep phase and duration disturbances.

Terman M, Lewy AJ, Dijk DJ, Boulos Z, Eastman CI, Campbell SS.

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Advanced and delayed sleep phase disorders, and the hypersomnia that can accompany winter depression, have been treated successfully by appropriately timed artificial bright light exposure. Under entrainment to the 24-h day-night cycle, the sleep-wake pattern may assume various phase relationships to the circadian pacemaker, as indexed, for example, by abnormally long or short intervals between the onset of melatonin production or the core body temperature minimum and wake-up time. Advanced and delayed sleep phase syndromes and non-24-h sleep-wake syndrome have been variously ascribed to abnormal intrinsic circadian periodicity, deficiency of the entrainment mechanism, or--most simply--patterns of daily light exposure insufficient for adequate phase resetting. The timing of sleep is influenced by underlying circadian phase, but psychosocial constraints also play a major role. Exposure to light early or late in the subjective night has been used therapeutically to produce corrective phase delays or advances, respectively, in both the sleep pattern and circadian rhythms. Supplemental light exposure in fall and winter can reduce the hypersomnia of winter depression, although the therapeutic effect may be less dependent on timing.

Biol Psychiatry 1999 Aug 15;46(4):445-53

Sleep deprivation in depression: what do we know, where do we go?

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Manipulations of the sleep-wake cycle, whether of duration (total or partial sleep deprivation [SD]) or timing (partial SD, phase advance), have profound and rapid effects on depressed mood in 60% of all diagnostic subgroups of affective disorders. Relapse after recovery sleep is less when patients are receiving medication; it may be prevented by co-administration of lithium, pindolol, serotonergic antidepressants, bright light, or a subsequent phase advance procedure. Diurnal and day-to-day mood variability predict both short-term response to SD and long-term response to antidepressant drug treatment. These mood patterns can be understood in terms of a "two-process model of mood regulation" based on the model well established for sleep regulation: the interaction of circadian and homeostatic processes. The therapeutic effect of SD is postulated to be linked to changes in disturbed circadian- and sleep-wake-dependent phase relationships and concomitant increase of slow-wave-sleep pressure; additionally, SD-induced sleepiness may counteract the hyperarousal state in depression. This model has the advantage of providing a comprehensive theoretical framework and stringent protocols ("constant routine," "forced desynchrony") to dissect out specific disturbances. Many aspects tie in with current serotonergic receptor hypotheses of SD action. A treatment inducing euthymia in severely depressed patients within hours is an important therapeutic option that has come of age for clinical use.

Biol Rhythm Res 2000 Feb;31(1):88-107 Related Articles, Books, LinkOut

Estimates of the daily phase and amplitude of the endogenous component of the circadian rhythm of core temperature in sedentary humans living nychthemerally.

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Fifteen healthy female subjects were studied for eight days while living conventionally. Subjects were free to choose the ways they spent their time within a framework of regular times of retiring and rising; in practice, much of the waking time was spent in sedentary activities. Nine of the subjects were aware of the natural light-dark cycle, this approximating to a 12:12 L:D schedule at the time of year when the study took place. Before the study, subjects were assessed for their degree of "morningness" by questionnaire; throughout the study, they wore a rectal probe, and an activity meter on their non-dominant wrist. The timing (phase) and amplitude of the circadian rectal temperature rhythm were assessed on each day by cosinor analysis as well as by a method based on visual inspection of the data. These two parameters were also assessed after the temperature data for each day had been "purified" by a number of methods. From these results it was possible to investigate the effect of purification upon the amplitude of the circadian rhythm of temperature. Also, the day-by-day variability of phase, and the relationship between morningness and phase, were compared using these methods of phase estimation, and using cross-correlation between data sets from adjacent days; in all cases, raw and purified temperature data were used. There was a significantly greater amount of daily variation in phase using purified rather than raw data sets, and this difference was present with all methods of purification as well as with all methods for estimating phase. Purification decreased the amplitude of the circadian temperature rhythm by about 30%. Finally, there was a significant correlation between the morningness score of the subjects and the phase of the circadian temperature rhythm, the phase becoming earlier with increasing morningness; when this relationship was re-examined using purified data, it became more marked. These results reflect the masking effects exerted upon raw temperature data by lifestyle. The extent to which the purification methods enable the endogenous component of a circadian rhythm - and, by implication, the output of the endogenous circadian oscillator - to be estimated in subjects living normally is addressed.

J Biol Rhythms 1999 Jun;14(3):237-53 Related Articles, Books, LinkOut

Melatonin rhythm observed throughout a three-cycle bright-light stimulus designed to reset the human circadian pacemaker.

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Exposure to light and darkness can rapidly induce phase shifts of the human circadian pacemaker. A type 0 phase response curve (PRC) to light that has been reported for humans was based on circadian phase data collected from constant routines performed before and after a three-cycle light stimulus, but resetting data observed throughout the entire resetting protocol have not been previously reported. Pineal melatonin secretion is governed by the hypothalamic circadian pacemaker via a well-defined neural pathway and is reportedly less subject to the masking effects of sleep and activity than body temperature. The authors reasoned that observation of the melatonin rhythm throughout the three-cycle light resetting trials could provide daily phase-resetting information, allowing a dynamic view of the resetting response of the circadian pacemaker to light. Subjects (n = 12) living in otherwise dim light (approximately 10-15 lux) were exposed to a noncritical stimulus of three cycles of bright light (approximately 9500 lux for 5 h per day) timed to phase advance or phase delay the human circadian pacemaker; control subjects (n = 11) were scheduled to the same protocols but exposed to three 5-h darkness cycles instead of light. Subjects underwent initial and final constant routine phase assessments; hourly melatonin samples and body temperature data were collected throughout the protocol. Average daily phase shifts of 1 to 3 h were observed in 11 of 12 subjects receiving the bright light, supporting predictions obtained using Kronauer's phase-amplitude model of the resetting response of the human circadian pacemaker. The melatonin rhythm in the 12th subject progressively attenuated in amplitude throughout the resetting trial, becoming undetectable for >32 hours preceding an abrupt reappearance of the rhythm at a shifted phase with a recovered amplitude. The data from control subjects who remained in dim lighting and darkness delayed on average -0.2 h per day, consistent with the daily delay expected due to the longer than 24-h intrinsic period of the human circadian pacemaker. Both temperature and melatonin rhythms shifted by equivalent amounts in both bright light-treated and control subjects ($R = 0.968$; $p<0.0001$; $n = 23$). Observation of the melatonin rhythm throughout a three-cycle resetting trial has provided a dynamic view of the daily phase-resetting response of the human circadian pacemaker. Taken together with the observation of strong type 0 resetting in humans in response to the same three-cycle stimulus applied at a critical phase, these data confirm the importance of considering both phase and amplitude when describing the resetting of the human circadian pacemaker by light.

J Sleep Res 1992 Mar;1(1):17-23 Related Articles, Books, LinkOut

Effects of evening bright light exposure on melatonin, body temperature and sleep.

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Five male subjects were exposed to a single 2-h period of bright (2500 lux) or dim (<100 lux) light prior to sleep on two consecutive nights. The two conditions were repeated the following week in opposite order. Bright light significantly suppressed salivary melatonin and raised rectal temperature 0.3 degrees C (which remained elevated during the first 1.5 h of sleep), without affecting tympanic temperature. Bright light also increased REM latency, NREM period length, EEG spectral power in low frequency, 0.75-8 Hz and sigma, 12-14 Hz (sleep spindle) bandwidths during the first hour of sleep, and power of all frequency bands (0.5-32 Hz) within the first NREMP. Potentiation of EEG slow wave activity (0.5-4.0 Hz) by bright light persisted through the end of the second NREMP. The enhanced low-frequency power and delayed REM sleep after bright light exposure could represent a circadian phase-shift and/or the effect of an elevated rectal temperature, possibly mediated by the suppression of melatonin.

Sleep 1998 Mar 15;21(2):154-65 Related Articles, Books, LinkOut

Medium-intensity light produces circadian rhythm adaptation to simulated night-shift work.

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STUDY OBJECTIVES: To assess the effect of nocturnal light intensity on circadian adaptation to simulated night work. SETTING AND PARTICIPANTS: Normal young men and women, simulated night work, home sleep. DESIGN AND MEASUREMENTS: We compared temperature rhythm phase shifts following timed exposure to high (approximately 5700 lux 3 hours/day), medium (approximately 1230 lux 3 hours/day) or constant low-intensity (< 250 lux) light during consecutive night shifts. Subjects (n = 35) followed a schedule of 7 days baseline, 6 days of 8-hour night shifts (with day sleep delayed 10 hours from baseline sleep), and 4 days of recovery. Subjects wore dark sunglasses while outdoors during daylight. Sleep logs were completed after each 8-hour sleep/dark period. Night work fatigue was rated by questionnaire. RESULTS: During the 3rd through 5th days of night work, most subjects in the high and medium groups (100% and 85%) exhibited phase delays large enough that their body temperature minima occurred within the daytime sleep/dark period. Only 42% of subjects in the low group exhibited phase delays large enough to meet this criterion of circadian adaptation. The phase shifts of the high and medium groups were not significantly different, and were significantly different from the low group. Larger phase shifts were correlated with more sleep and less fatigue. CONCLUSIONS: Extremely "bright" light may not be necessary for circadian adaptation in shift work situations similar to our study protocol (e.g., regular daytime sleep/dark periods, sunglasses).

J Physiol 1996 Aug 15;495 (Pt 1):289-97 Related Articles, Books, LinkOut

Phase-shifting human circadian rhythms: influence of sleep timing, social contact and light exposure.

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1. Both the timing of behavioural events (activity, sleep and social interactions) and the environmental light-dark cycle have been reported to contribute to entrainment of human circadian rhythms to the 24 h day. Yet, the relative contribution of those putative behavioural synchronizers to that of light exposure remains unclear. 2. To investigate this, we inverted the schedule of rest, sedentary activity and social contact of thirty-two young men either with or without exposure to bright light. 3. On this inverted schedule, the endogenous component of the core temperature rhythm of subjects who were exposed to bright light showed a significant phase shift, demonstrating that they were adapting to the new schedule. In contrast, the core temperature rhythm of subjects who were not exposed to bright light moved on average 0.2 h later per day and after 10 days had not significantly adapted to the new schedule. 4. The direction of phase shift in the groups exposed to bright light was dependent on the time of bright light exposure, while control subjects drifted to a later hour regardless of the timing of their schedule of sleep timing, social contact and meals. 5. These results support the concept that the light-dark cycle is the most important synchronizer of the human circadian system. They suggest that inversion of the sleep-wake, rest-activity and social contact cycles provides relatively minimal drive for resetting the human circadian pacemaker. 6. These data indicate that interventions designed to phase shift human circadian rhythms for adjustment to time zone changes or altered work schedules should focus on properly timed light exposure.

Sleep 1994 Sep;17(6):535-43 Related Articles, Books, LinkOut

Dark goggles and bright light improve circadian rhythm adaptation to night-shift work.

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We compared the contributions of bright light during the night shift and dark goggles during daylight for phase shifting the circadian rhythm of temperature to realign with a 12-hour shift of sleep. After 10 baseline days there were 8 night-work/day-sleep days. Temperature was continuously recorded from 50 subjects. There were four groups in a 2 x 2 design: light (bright, dim), goggles (yes, no). Subjects were exposed to bright light (about 5,000 lux) for 6 hours on the first 2 night shifts. Dim light was < 500 lux. Both bright light and goggles were significant factors for producing circadian rhythm phase shifts. The combination of bright light plus goggles was the most effective, whereas the combination of dim light and no goggles was the least effective. The temperature rhythm either phase advanced or phase delayed when it aligned with daytime sleep. However, when subjects did not have goggles only phase advances occurred. Goggles were necessary for producing phase delays. The most likely explanation is that daylight during the travel-home window after a night shift inhibits phase-delay shifts, and goggles can prevent this inhibition. Larger temperature-rhythm phase shifts were associated with better subjective daytime sleep, less subjective fatigue and better mood.

Clin Endocrinol (Oxf) 1994 Mar;40(3):413-20 Related Articles, Books, LinkOut

Phase-shifts in melatonin, 6-sulphatoxymelatonin and alertness rhythms after treatment with moderately bright light at night.

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OBJECTIVES: Shift work and rapid travel across several time zones leads to desynchronization of internal circadian rhythms from the external environment and from each other with consequent problems of behaviour, physiology and performance. Field studies of travellers and shift workers are expensive and difficult to control. This investigation concerns the simulation of such rhythm disturbance in a laboratory environment. The main objectives are to assess the ability of controlled exposure to moderately bright light and darkness/sleep to delay circadian rhythms in volunteers without environmental isolation and, secondly, to evaluate the use of different indices of melatonin (MT) secretion together with self-rated alertness as marker rhythms. PATIENTS: Six normal volunteers aged 22-26 years (mean +/- SD 24.3 +/- 1.4). DESIGN: Subjects were exposed to the following periods of moderately bright light (1200 lux) on three consecutive days in early December 1991: Day (D)1: 2000-0200 h, D2: 2200-0400 h and D3: 2400-0600 h. Each period was followed by 8 hours of darkness (< 1 lux). Hourly blood, sequential 4-hourly urine (8-hourly when asleep) and hourly saliva (except when asleep) samples were taken throughout a 24-hour period on D0 (baseline), D4 (1 day post-light treatment) and D7 (4 days post-light treatment). During waking hours, subjective alertness was rated every 2 hours on a visual analogue scale. MEASUREMENTS: MT was measured in plasma and saliva, and its metabolite, 6-sulphatoxymelatonin (aMT6s), was measured in urine. MT, aMT6s and alertness scores were analysed by ANOVA and a cosinor analysis program. RESULTS: A delay shift was present in the aMT6s, plasma MT and salivary MT rhythms (degree of shift: 2.67 +/- 0.3 h ($P < 0.001$, $n = 5$); 2.35 +/- 0.29 h ($P < 0.001$, $n = 6$); and 1.97 +/- 0.32 h ($P < 0.01$, $n = 6$), mean +/- SEM, respectively) 1 day post-light treatment compared to baseline. Adaptation to the initial phase position was apparent by the 4th post-treatment day. Significant correlations were obtained between plasma MT onset (degree of shift: 3.12 +/- 0.74 h ($P < 0.001$, $n = 6$, mean +/- SEM)) and the acrophases (calculated peak times) of plasma MT ($P < 0.001$), salivary MT ($P < 0.05$) and urinary aMT6s ($P < 0.01$). A significant phase delay in the alertness rhythm was also evident 1 day post-treatment (3.08 +/- 0.67 h ($P < 0.01$, $n = 6$, mean +/- SEM)) with adaptation by the 2nd post-treatment day. CONCLUSIONS: This study suggests that these methods of determining MT secretion are comparable and give reliable assessments of the MT circadian phase position even after a phase-shift. Significant phase-shifts of similar magnitude can be induced in both MT and alertness rhythms using moderate intensity bright light at night.

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Phase-shifts in melatonin, 6-sulphatoxymelatonin and alertness rhythms after treatment with moderately bright light at night.

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Sleep 1991 Dec;14(6):511-6 Related Articles, Books, LinkOut

Timed exposure to bright light improves sleep and alertness during simulated night shifts.

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Many of the health and safety problems reported by shift workers result from the chronic sleep deprivation associated with shorter, fragmented daytime sleep. This reduction in the quality and duration of sleep has been attributed to a change in the phase relationship between the work period and the circadian system, timing the propensity for sleep and wakefulness. This study examined the extent to which appropriately timed exposure to bright light would accelerate the circadian readjustment of physiological parameters thought to contribute to impaired performance in shift workers. A control (n = 7) and treatment group (n = 6) underwent a 3-day transition to simulated night work. The treatment group received a single 4-hour pulse of bright light (6,000 lux) between 2400 and 0400 hours on the first night shift and dim light (less than 200 lux) for the remainder of the study. The control group received dim light throughout. By the third night shift, the phase position of the core body temperature rhythm for the treatment group had delayed by 5-6 hours whereas the control group had delayed by only 2-3 hours. When compared to the control group, the greater delay in core temperature rhythm for the treatment group was associated with significantly higher alertness across the night shift and improved sleep quality during the day. By the third day sleep, mean sleep efficiency in the treatment group was not significantly different from normal night sleep. Similarly, onshift alertness was improved relative to the control group. The treatment group did not show the typical decline in alertness observed in the control group between 0300 and 0700 hours. These data indicate that a single 4-hour pulse of bright light between midnight and 0400 hours is effective in ameliorating the sleep and alertness problems associated with transition to night shift.

J Am Geriatr Soc 1993 Aug;41(8):829-36 Related Articles, Books, LinkOut

Alleviation of sleep maintenance insomnia with timed exposure to bright light.

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OBJECTIVE: Half of the population over 65 suffers from chronic sleep disturbance. As a consequence, almost 40% of hypnotic medications are prescribed to people over age 60. Yet, hypnotics are often of little benefit in this population. As such, an effective non-drug alternative could prove important in the management of age-related sleep maintenance insomnia. The current study sought to evaluate the efficacy of bright light exposure in the treatment of sleep maintenance insomnia. DESIGN: Following baseline sleep and circadian rhythms assessment, subjects with sleep-maintenance insomnia were treated with timed exposure to either bright white light or dim red light for 12 consecutive days. Sleep and circadian rhythms recordings were subsequently obtained and measures of sleep quality were compared to assess efficacy of the treatments. SETTING: Baseline and post-treatment sleep and circadian rhythms assessments took place in the Laboratory of Human Chronobiology, Department of Psychiatry, Cornell University Medical College. The treatment phase of the study was conducted in participants' homes. PARTICIPANTS: Sixteen men and women between the ages of 62 and 81 years were studied. All subjects were free of hypnotic medication, and all had experienced sleep disturbance for at least 1 year prior to entering the study. RESULTS: Exposure to bright light resulted in substantial changes in sleep quality. Waking time within sleep was reduced by an hour, and sleep efficiency improved from 77.5% to 90%, without altering time spent in bed. Increased sleep time was in the form of Stage 2 sleep, REM sleep, and slow wave sleep. The effects were remarkably consistent across subjects. CONCLUSIONS: The findings demonstrate the effectiveness of timed exposure to bright light in the treatment of age-related sleep maintenance insomnia. With further refinement of treatment regimens, this non-drug intervention may prove useful in a large proportion of sleep disturbed elderly.