Chapter 16

Using Bright Light and Melatonin to Reduce Jet Lag

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PROTOCOL NAME

Using bright light and melatonin to reduce jet lag.

GROSS INDICATION

This is generally applicable to phase shifting the circadian clock in patients with circadian rhythm sleep disorders or winter depression.

SPECIFIC INDICATION

Bright light and melatonin can be used to reduce jet lag after crossing at least two time zones east or west.

CONTRAINDICATIONS

Bright light should probably not be used in:

- people with existing eye disease;
- people using photosensitizing medications.

Bright light can induce:

- migraines (in about one-third of migraine sufferers);
- mania (rare).

Melatonin should probably not be used in:

- people who are driving or operating heavy machinery (unless they have previously tested their response to melatonin and are taking $<0.5\,mg$ of melatonin);
- pregnant or nursing women (melatonin will transfer to the fetus/infant);
- women seeking to become pregnant;

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- children (unless they suffer from a neurodevelopmental condition associated with extremely poor sleep);
- asthmatics and patients with gastrointestinal disease (melatonin may be inflammatory);
- patients using other medications (unless supervised by a physician).

RATIONALE FOR INTERVENTION

Rapid jet travel across multiple time zones produces a temporary misalignment between the timing of the central circadian clock and the desired sleep times in the new time zone. This circadian misalignment often leads to nighttime insomnia (early insomnia after flying east, late insomnia after flying west), daytime sleepiness, worsened mood, and gastrointestinal disturbances. Bright light and melatonin can be used to accelerate the shifting of the circadian clock such that the circadian misalignment is minimized and the severity and duration of jet lag are reduced.

STEP BY STEP DESCRIPTION OF PROCEDURES

Jet lag can be minimized with some preflight planning.

The first step is to estimate the timing of the minimum of your core body temperature rhythm ("T_{min}"). A general rule of thumb is that it occurs 3 hours before your habitual wake-up time [1].

The second step is to determine your flight schedule, including stopovers, direction of travel, when you would like to sleep at your destination, the time difference between home and your destination, and sunrise and sunset times at your destination (www.timeanddate.com is a useful website). When flying west, the circadian clock needs to shift later in time ("phase delay") to adjust to the new time zone. In general, when flying east the circadian clock needs to shift earlier in time ("phase advance") to adjust to the new time zone. However, eastward jet travel across eight or more time zones can be difficult to adjust to [2,3], and in this case the circadian clock will often phase delay.

The third step is to determine when to seek light and to avoid light to accelerate the shifting of your circadian clock. To phase delay, you need to seek light in at least the 4 hours before your T_{min} and avoid light in at least the 4 hours after your T_{min} [4]. To phase advance, you need to avoid light in at least the 4 hours before your T_{min} and seek light in at least the 4 hours after your T_{min} [4]. You can seek light by staying awake, by going outdoors and not wearing sunglasses, or by using a commercially available portable light box. You can avoid light by sleeping in a dark bedroom, staying indoors away from windows, wearing orange "blue blockers" glasses when inside, and wearing very dark sunglasses if you must go outside.

Studies of jet travelers who did not regulate their light exposure indicate people can phase delay up to 1.5 hours per day and phase advance up to 1 hour per day [2,3,5]. The more successful you are at seeking and avoiding light at the correct times, the more likely you will be able to phase delay about 2 hours per day and phase advance about 1.5 hours per day. Your success depends on having a flexible schedule, and, if you do not have a portable light box, good weather and reasonable temperatures that permit you to stay outside and receive light at the required times.

The fourth step is to consider if your schedule (including the required wake-up time to catch your flight) permits gradually shifting your sleep in the direction of travel in the days *before* your departure. This approach shifts your sleep and circadian clock together, and so does not produce circadian misalignment and jet lag [6,7]. Instead it reduces how much your circadian clock needs to shift on arrival, thereby reducing your jet lag. Preflight shifts are particularly beneficial for people traveling east, as preflight shifts increase your chances of getting bright light at the correct time on arrival, further facilitating phase advances. If you are traveling east, you will need to shift your habitual bed and wake times 1 hour earlier per day and maximize your bright light exposure in the first 3–4 hours after you wake up each morning. If you are traveling west, you will need to shift your habitual bed and wake times 1 hour later per day and maximize your bright light exposure in the 3–4 hours before your bedtime each night. Such a preflight regimen can phase advance the circadian clock 30–45 minutes per day [6], and phase delay the circadian clock by about 1 hour per day [8].

The fifth step is to consider taking melatonin to enhance your phase shifts to bright light. Phase advances in response to bright light can be further increased to about 1 hour per day if you take 0.5 mg of melatonin 10 hours before your T_{min} [7]. It is not yet known if phase delays in response to bright light can be further increased with melatonin.

The sixth step is to draw your jet lag plan containing all of the above elements. The jet lag plan should guide you on when to seek and avoid light, and can be stopped once you are sleeping well at night and performing well during the day in the new time zone.

Figures 16.1–16.3 display some examples of jet lag plans for a nonstop Los Angeles to Paris return flight. Los Angeles to Paris is an eastward flight across nine time zones. Such eastward flights are particularly difficult to adjust to, and phase delays often result.

Figure 16.1 shows a traveler, who normally sleeps 11 pm to 7 am in Los Angeles (T_{min} at 4 am) arriving in Paris without a preflight shift. As this traveler arrives in Paris in the early morning and moves through immigration, baggage claim and customs, and transits to her hotel, she is likely to receive significant bright light exposure immediately before her T_{min}. As phase advancing in these circumstances will be extremely difficult, this traveler instead plans to use this light exposure to help her phase delay. Even if she seeks and avoids light at the correct times, she is still likely to experience jet lag for 6–7 days, until her T_{min} falls into her desired sleep times.

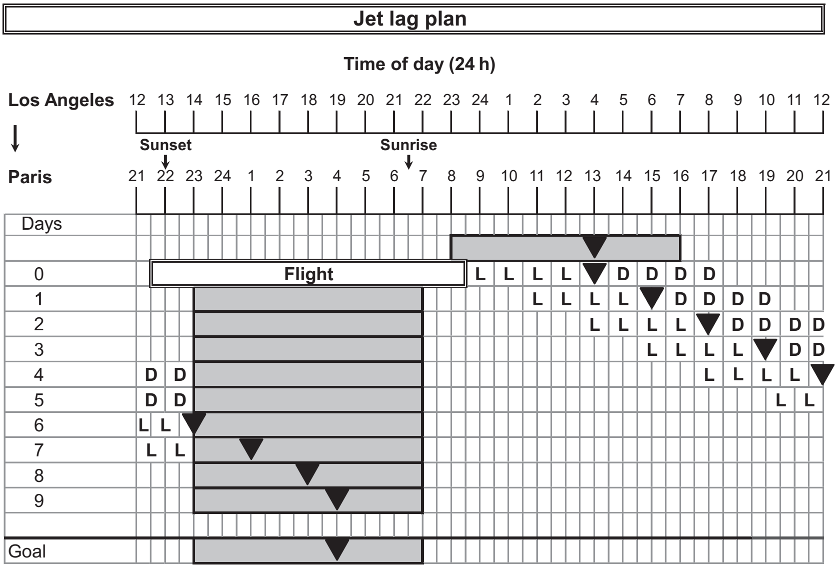

FIGURE 16.1 A jet-lag plan for a traveler who travels non-stop from Los Angeles to Paris with no preflight shift. The triangle represents the minimum of her core body temperature rhythm, T_{min}. L = when to seek light, D = when to seek dark.

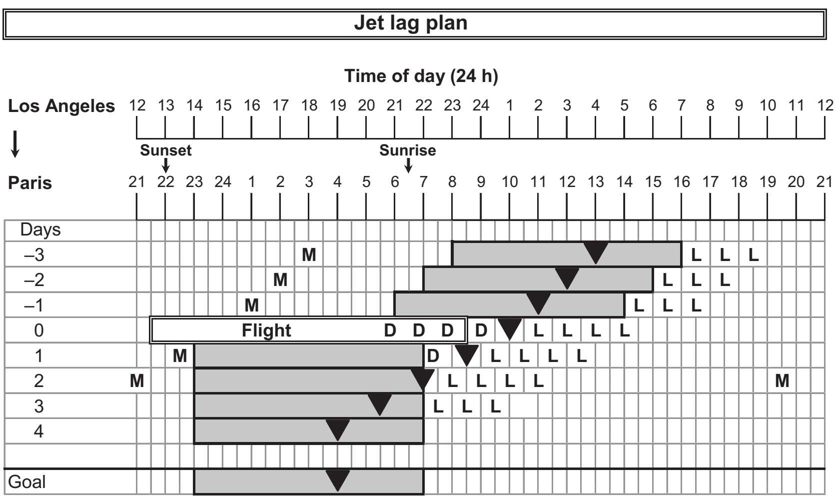

FIGURE 16.2 A jet-lag plan for a traveler who travels non-stop from Los Angeles to Paris with a 3-day preflight shift. The triangle represents the minimum of her core body temperature rhythm, T_{min}. L = when to seek light, D = when to seek dark, M = time to take 0.5 mg melatonin.

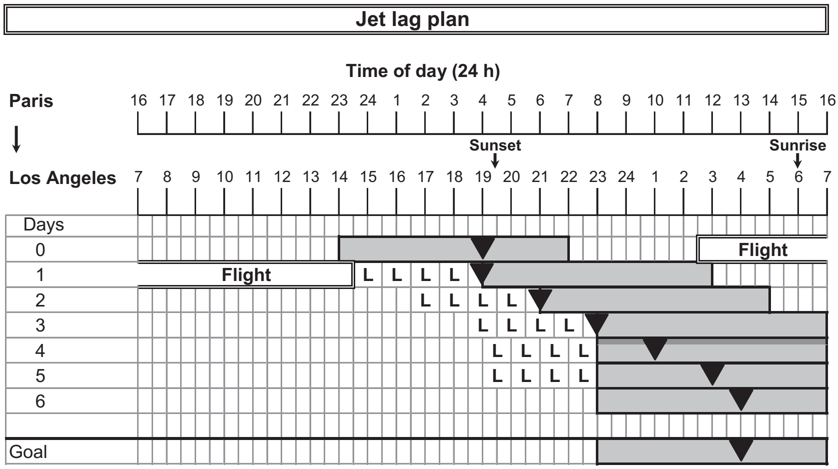

FIGURE 16.3 A jet-lag plan for a traveler who travels non-stop from Paris to Los Angeles with no preflight shift. The triangle represents the minimum of her core body temperature rhythm, T_{min}. L = when to seek light, D = when to seek dark.

Figure 16.2 shows the same traveler arrive in Paris after a 3-day preflight shift. In this case, the time interval during which she must avoid light after arrival in Paris is 3 hours shorter and she anticipates that by the time she transits to her hotel it will be time to seek light. After a quick shower, she sits outside with her laptop or good book to ensure she gets plenty of bright light. With this plan, she should experience jet lag for 3–4 days.

Figure 16.3 shows her return flight. This time, light exposure on her arrival in Los Angeles is beneficial and she has a flexible schedule such that at 7 pm she goes to sleep in a dark bedroom to ensure she avoids light after her T_{min}. With this strategy, she will likely experience jet lag for 3–4 days.

POSSIBLE MODIFICATIONS/VARIANTS

Jet lag will often worsen as we age. While older people can still phase shift as effectively to bright light as younger people [9], older people are more sensitive to circadian misalignment [10].

Morning types typically have earlier T_{min}s [11], and so may adjust better than most to eastward flights. Evening types typically have later T_{min}s [11], and so may adjust better than most to westward flights.

Commercially available light boxes vary in their size, portability, and wavelength. Generally, larger light boxes, which cover more of the visual field, are less aversive, but smaller light boxes are more portable. Current research suggests bright blue-light boxes are no more effective than bright white-light boxes [8,12].

Exposure to bright light does not have to be continuous for several hours in order to be effective. Intermittent light can still be effective in phase shifting the circadian clock [6,13], and people can take breaks from light exposure by going inside for short periods of time, or stepping away from the light box in order to shower, dress, and prepare meals. Nonetheless, the more exposure to bright light at the correct times, the better.

PROOF OF CONCEPT/SUPPORTING DATA/EVIDENCE BASE

More field studies on phase shifts to bright light and melatonin in jet travelers are needed. However, the results of three field studies indicate that bright light and melatonin at the correct times can help reduce jet lag:

A study of 20 jet travelers reported that the more closely the travelers sought and avoided light at predetermined times, the less jet lag they reported [14].

A study of 15 jet travelers showed that the use of bright light at predetermined times significantly reduced the severity of self-reported jet lag symptoms as compared to no bright light [15].

A study of 6 jet travelers who flew eastward found that melatonin taken at the correct time accelerated phase shifts to the new time zone more than placebo [16].

REFERENCES

[1] J. Carrier, T.H. Monk, C.F. Reynolds, D.J. Buysse, D.J. Kupfer, Are age differences in sleep due to phase differences in the output of the circadian timing system?, Chronobiol. Int. 16 (1999) 79–91.

[2] T. Takahashi, M. Sasaki, H. Itoh, et al., Re-entrainment of circadian rhythm of plasma melatonin on an 8-h eastward flight, Psychiatry Clin. Neurosci. 53 (1999) 257–260.

[3] T. Takahashi, M. Sasaki, H. Itoh, et al., Re-entrainment of the circadian rhythms of plasma melatonin in an 11-h eastward bound flight, Psychiatry Clin. Neurosci. 55 (2001) 275–276.

[4] V.L. Revell, C.I. Eastman, How to trick mother nature into letting you fly around or stay up all night, J. Biol. Rhythms 20 (2005) 353–365.

[5] J. Aschoff, K. Hoffmann, H. Pohl, R. Wever, Re-entrainment of circadian rhythms after phase shifts of the zeitgeber, Chronobiologia 2 (1975) 23–78.

[6] H.J. Burgess, S.J. Crowley, C.J. Gazda, et al., Preflight adjustment to eastward travel: 3 days of advancing sleep with and without morning bright light, J. Biol. Rhythms 18 (2003) 318–328.

[7] V.L. Revell, H.J. Burgess, C.J. Gazda, et al., Advancing human circadian rhythms with afternoon melatonin and morning intermittent bright light, J. Clin. Endocrinol. Metab. 91 (2006) 54–59.

[8] M.R. Smith, C.I. Eastman, Phase delaying the human circadian clock with blue-enriched polychromatic light, Chronobiol. Int. 26 (4) (2009) 709–725.

[9] J.F. Duffy, J.M. Zeitzer, C.A. Czeisler, Decreased sensitivity to phase-delaying effects of moderate intensity light in older subjects, Neurobiol. Aging 28 (5) (2007) 799–807.

[10] M.L. Moline, C.P. Pollak, T.H. Monk, et al., Age-related differences in recovery from simulated jet lag, Sleep 15 (1992) 28–40.

[11] E.K. Baehr, W. Revelle, C.I. Eastman, Individual differences in the phase and amplitude of the human circadian temperature rhythm: with an emphasis on morningness–eveningness, J. Sleep Res. 9 (2000) 117–127.
[12] M.R. Smith, V.L. Revell, C.I. Eastman, Phase advancing the human circadian clock with blue-enriched polychromatic light, Sleep Med. 10 (2009) 287–294.
[13] D.W. Rimmer, D.B. Boivin, T.L. Shanahan, et al., Dynamic resetting of the human circadian pacemaker by intermittent bright light, Am. J. Physiol. 279 (2000) R1574–R1579.
[14] D.Z. Lieberman, An automated treatment for jet lag delivered through the internet, Psychiatric Serv. 54 (2003) 394–396.
[15] T. Lahti, J. Terttunen, S. Leppamaki, et al., Field trial of timed bright light exposure for jet lag among airline cabin crew, Int. J. Circumpolar Health 66 (4) (2007) 365–369.
[16] T. Takahashi, M. Sasaki, H. Itoh, et al., Effect of 3 mg melatonin on jet lag syndrome in an 8-h eastward flight, Psychiatry Clin. Neurosci. 54 (2000) 377–378.

RECOMMENDED READING

C.I. Eastman, H.J. Burgess, How to travel the world without jet lag, Sleep Med. Clin. 4 (2009) 241–255.

J. Waterhouse, T. Reilly, G. Atkinson, B. Edwards, Jet lag: trends and coping strategies, Lancet 369 (2007) 1117–1129.

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Chapter 17

Using Bright Light and Melatonin to Adjust to Night Work

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PROTOCOL NAME

Using bright light and melatonin to adjust to night work.

GROSS INDICATION

This protocol is indicated for people who want to work on a later schedule.

SPECIFIC INDICATION

This use of bright light and melatonin is specifically indicated for people who are working at least 2 consecutive weeks of night shifts, and particularly for workers engaged in high-risk work, such as nuclear power plant operators and health care workers.

CONTRAINDICATIONS

As the circadian system is slow to shift, phase shifting the circadian clock is not useful for people working for less than 2 consecutive weeks of night shifts, such as part of a rapidly rotating work shift schedule.

Bright light should probably not be used in:

- people with existing eye disease;
- people using photosensitizing medications.

Bright light can induce:

- migraines (in about a third of migraine sufferers);
- mania (rare).

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