ASSESSMENT AND MODIFICATION OF A HUMAN SUBJECT'S CIRCADIAN CYCLE

STATEMENT ACKNOWLEDGING GOVERNMENT SUPPORT

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This application is a continuation of applications Ser. No. 07/521,041, filed May 9, 1990 U.S. Pat. No. 5,167,228 and Ser. No. 07/365,949, filed Jun. 15, 1989 U.S. Pat. No. 5,176,133, both of which are continuations-in-part of application Ser. No. 07/066,677 filed Jun. 26, 1987 U.S. Pat. No. 5,163,426.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods and devices for assessing and modifying the circadian cycle in humans. More specifically, the invention relates to methods and devices for using scheduled exposure to bright light and advantageously also periods of darkness or diminished light, to alter the circadian cycle of humans to a desired phase and amplitude.

2. Related Art

It is known in the art that humans exhibit circadian (daily) cycles in a variety of physiologic, cognitive, and behavioral functions. The cycles are driven by an internal biological clock or circadian pacemaker which has been located in the brain and are not just passive responses to periodic environmental changes. It is known that humans exhibit different degrees of alertness, performance, and proneness to accidents at different phases in their circadian cycle.

Often, the activities in which humans wish to engage do not coincide in time with the most appropriate point in the circadian cycle. For instance, transmeridian travelers experience what is commonly referred to as "jet lag." This phenomenon occurs when the internal, physiological circadian phase of the traveler has not yet adapted to the geophysical time of his destination. Individuals who travel from west to east often experience sleeplessness late in the evening at their destination, with a corresponding difficulty in awakening on time in the morning. Similarly, those who travel from east to west often experience a tendency to sleep earlier in the evening and arise earlier in the morning than is appropriate for the locale of their destination. The travelers' internal, physiological cycle lags (or leads) their desired activity-rest cycle. Symptoms are worse and last longer when travelers must cross more than three or four time zones, especially when traveling west to east. West to east travel is more difficult than east to west travel because the intrinsic period of the human circadian pacemaker is greater than 24 hours (averaging about 24.3 to 25.0 hours in normal young men). Therefore, in the absence of an environmental synchronizing cue, the phase position of the pacemaker tends to drift to a later hour (i.e., in a manner equivalent to westward travel at a rate of about one time zone per 1 to 2 days). The insomnia associated with jet lag may be postponed two or three days if the travelers are sleep-deprived as a result of the journey, since sleep deprivation makes it easier to sleep at an adverse circadian phase. However, the essential circadian nature of jet lag is demonstrated by nocturnal insomnia and excessive daytime sleepiness which typically occur within two to three days of arrival.

In a similar fashion, people who work in professions requiring them to work at night, such as factory workers, medical personnel, police, and public utilities personnel, experience a desynchrony between the activities in which they desire to engage and their physiological ability to engage in such activities. Such "shift workers" often experience an inability to sleep soundly during their non-working hours. This misalignment between internal circadian phase and scheduled work hours at night also manifests as increased drowsiness during the early morning hours of 3:00–7:00 a.m., assuming a habitual waketime of 7:00 to 8:00 a.m. (These times would be modified if the habitual waketime were at a different hour.) It is during this time frame that most people's circadian cycles are at their troughs, implying that they experience minimum alertness and maximum proneness to accident or error. These workers then experience corresponding difficulty sleeping during the daytime hours after they have worked at night, again because of circadian phase misalignment. This results in sleep deprivation, which exacerbates the problem they experience with alertness and performance on their subsequent night shifts. For workers in the medical field or for those individuals who monitor the processes in nuclear power plants, for example, such decreased alertness can have (and already may have had) disastrous consequences.

Three different approaches have been used previously to reduce the deleterious effects of shift work schedules on the performance of shift workers and the safety of shift work operations. One, used primarily in Europe, is to very rapidly rotate shift workers such that they never work more than 1–2 night shifts in a row and do not attempt to adapt to night shift work. The second approach is to select shift workers on the basis of the amplitude of the temperature cycle for shift work, since it has been reported that individuals with certain characteristics of temperature cycle amplitude can adapt more easily to rotating shift work schedules (see A. Reinberg et al., "Circadian Rhythm Amplitude and Individual Ability to Adjust to Shift Work." *Ergonomics,* Vol. 21 (1978), pp. 763–766). The third approach has been to apply circadian principles in the design of work schedules (see C. A. Czeisler et al., "Rotating Shift Work Schedules That Disrupt Sleep Are Improved by Applying Circadian Principles." *Science,* Vol. 210 (1980), pp. 1264–1276).

There are various categories of sleep-related and affective disorders which are thought to be related to misalignment between the internal circadian cycle and the external activity-rest cycle. For example, the elderly often experience a phase advance of the internal circadian pacemaker to an earlier hour, which manifests as a tendency to be fatigued and tired earlier in the evening, and to spontaneously awake earlier in the morning, than was the case earlier in their lives. Many elderly subjects also have a reduced amplitude of the endogenous component of the body temperature cycle, suggesting that the output of the circadian pacemaker may be attenuated with age. This may contribute to the increased tendency for both daytime napping and nocturnal arousals reported in the elderly.

Other sleep scheduling disorders not totally determined by age, such as delayed-sleep-phase insomnia, are