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Understanding How Travel Affects Your Sleep: The TLP SLEEP Solution

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Overview:

Any change in someone's environment can impact their sleep quality and habits. Travel, particularly across time zones, is one of the most intrusive changes that can affect sleep. The stress of preparing for a trip, dealing with airport security, and even the basic differences such as lighting, sound, smell, and allergens between your home and your destinations can affect the quality of your sleep. The biggest direct effect occurs when traveling through one or more time zones. This arises for the most part due to a mismatch between your brain's internal clock, called the suprachiasmatic nucleus, and the change in the external world. Your suprachiasmatic nucleus (SCN) sets your internal clock based on a number of environmental inputs, but the one that plays the strongest role in resetting your internal clock is light. The basic mechanism in setting your master clock works like this. Light from the environment enters your eye, is converted into bioelectrical impulses and are passed to your brain, splitting between parts of your brain that process vision and a separate pathway called the retinohypothalamic pathway (RHT) which sends light information to your suprachiasmatic nucleus. Output from the suprachiamstic nucleus affects every biological (and most psychological) functions, including blood pressure, heartrate, metabolic processes, alertness and, of course, sleep. It was originally thought that all light striking the retina contributed to maintaining the master clock, but recent studies have shown that there are a subset of neurons in the eye that do not contribute to vision at all, but only project to the SCN, and that these cells are particularly sensitive to light in the blue-green range, in which natural sunlight is rich (while many artificial light sources are not). This is why traveling to a place where the daytime is shifted (as in traveling east-west, yielding a change in light *phase*) or to a place with a different day length (as in traveling north-south, yielding a change in light *duration*) or can have such a profound effect on your sleep cycles..

The Challenges of Treating Travel Induced Sleep Problems

Travel induced sleep problems is a relatively new phenomenon at a biological level. Before the advent of air travel or high speed ground travel, humans never traveled fast enough to upset their internal rhythms. But with international business and leisure moving entire populations across large regions of the globe in a matter of hours, jet lag (closely related to shift work problems in people who have to work at odd or changing work hours) is so prevalent that it is now considered a serious sleep disorder. Casual travelers who only travel occasionally for short periods or are not crossing many time zones can benefit from simple techniques such as resetting their watches to match their destination's time when they get on a plane, not napping during travel, getting as much sunlight as possible on arrival and avoiding alcohol and caffeine. However, longer or more frequency trips across a greater range require more intervention to prevent serious cognitive or physiological effects. Adaptation to traveling east (which is harder on sleep cycles) can benefit to some degree from getting more sun exposure in the late morning, whereas westward travel benefits from getting more sun exposure in the late afternoon or evening, often in combination with taking melatonin right before bed (Zee and Goldstein, 2010). Travel from north to south imposes a different set of problems although it gets less attention. Daylength around the equator never changes much from 12 hours of light and 12 hours of darkness, but in the arctic and antarctic, there can be months of unending daylight or nighttime depending on latitude. In fact, the reindeer, a mammal that evolved and lives almost exclusively above the arctic circle is the only known mammal that lacks a master clock in the brain (Lu et al, 2010). Humans, who evolved in the more equatorial regions of Africa, often suffer from severe depression when spending significant amounts of time in the unending night time of these extreme regions. (At the other end of this spectrum are astronauts onboard the International Space Station who experience a sunrise and sunset every 20 minutes. Insomnia in spaceflight is a notorious problem, however, the factors underlying it are probably less from intermittent lighting cycles and more related to the disruption of the balance system and its connections to sleep centers).

Non-Light Based Aspects of Travel Can Affect Sleep and Circadian Time as Well

Light is not the only factor affecting the traveler's sleep cycle. Almost every type of sensation can affect sleep, although some are more intrusive than others. The funky smell that you can't quite identify in a hotel room or the slightly off taste of some airport food that may portend late night trips to the bathroom can certainly affect sleep but only in a transient way. Neither smell nor taste efficiently pierce the sleep barrier, which is why smoke alarms in hotel rooms make a piercing sound. Sound is a potent modifier of sleep cycles because it is detectable even during sleep (Velluti 1997). Because of this, sounds, particularly unfamiliar ones experienced in a new environment, are very likely to interrupt or prevent sleep (Vallet and Mouret, 1984). Travel to and from urban settings includes radical changes in background noise level which in turn have serious impacts on sleep and health in general (Moudon, 2009; Muzet, 2007). Noise around airports, including the hotels near them which are common destinations for business travelers, is typically significantly louder than in other urban or suburban regions and affects both travelers and residents, increasing blood pressure and heart rate, (Aydin & Kaltenbach, 2007) reducing sleep and generally decreasing cognitive performance in adults and children (Elmenhorst et al, 2010; Stansfeld et al, 2010).

In addition, the physical act of traveling, whether by road, sea or air, can directly affect sleep via the balance system. Low frequency, low amplitude vibration resulting from uneven road surfaces, waves on the ocean or the vibrations of an aircraft motor can cause a form of motion sickness called "Sopite syndrome" which leads to extreme lethargy (Graybiel & Knepton, 1976; Lawson & Mead, 1998). Sopite syndrome is estimated to effect over 60% of the population and is the underlying cause of many vehicular accidents where an otherwise healthy individual nods off at the wheel. While this might seem like a boon for long distance travelers, Sopite syndrome by itself does not induce normal sleep as much as extreme tiredness. Furthermore, sleeping on short flights or long road trips coupled with the other factors influencing the traveler, nodding off, but not truly sleeping, on a long flight cruise or drive, can exacerbate the problem of travel insomnia rather than help regulate sleep.

Treatments for Travel-Based Sleep Problems

Recommendations for travelers such as shifting time of exposure for sunlight or shifting ones watch to the destinations time mentioned earlier are often inconvenient or impossible to fit into a specific schedule. Other suggestions including avoiding alcohol or caffeine during travel (both of which exacerbate sleep difficulty) are helpful but still don't address the basic need to get proper sleep to enjoy a vacation or be capable of peak performance when traveling for business. Many travelers will use over the counter sleep aids such as melatonin, which is often recommended for shifting the sleep clock, but as an unregulated substance, there is great variability in strength and purity, not to mention the fact that users are taking very complicated compounds whose mechanisms are very poorly understood. Melatonin, while general considered safe in low dosages for short periods, is associated with diminished libido, headaches, nausea, grogginess and weight gain when taken in higher dosages.

Pharmaceutical sleep medications such as Ambien or Lunesta can have greater efficacy without some of the side effects of older sedatives, but also have mixed effectiveness in the greater population. These drugs target the nervous system's gamma-Aminobutyric acid (GABA) receptors. GABA is a very widespread inhibitory neurotransmitter that does much more than induce sleep, and side effects ranging from excessive daytime sleepiness to dizziness and loss of physical coordination.

TLP SLEEP Solution

One solution for developing a non-pharmaceutical sleep aid is to use the brains own sensory-sleep organization to prevent the roller coaster of drowsiness/wakefulness from insomnia by combining the two sensory systems most capable of affecting sleep cycles. Parents the world over know that you can rock your baby to sleep. And everyone has experienced being shaken awake. Both of these are balance responses – changes in acceleration that are measured by the other part of your inner ear, the vestibular system. Between these two extremes there is a psychophysical curve with sleep on one end and wakefulness on the other, both mediated by the inner ear. Advances in auditory neuroscience over the last decade have demonstrated that hearing and balance can cross talk under certain conditions (Todd & Cody, 2000). The next generation of sleep aids are here and use sound, but in a different way than music or sleep machines.

TLP SLEEP algorithms are based on two factors:

1) The vestibular system is profoundly interconnected with and effects substantial control over sleep processes; and

2) The auditory system has substantial functional and anatomical overlap with the vestibular system and is the sensory system most able to affect arousal under sleep and near-sleep conditions.

The vestibular system is important not only for maintaining balance and orientation, but it is also required for normal sleep. While the vestibular system is not part of the global "sleep regulatory system," vestibular stimulation modulates known arousal centers." Bidirectional connectivity between brainstem vestibular centers and arousal centers as well as multisynaptic connections with the mammalian master clock, the suprachiasmatic nucleus (Horowitz et al, 2005), indicate that vestibular input may be a potent modulator of sleep and arousal. There has been continuous attention to the possibility of a direct sleep-vestibular system connection since the 1960's (Leslie et al. 1997). The problematic interaction of the vestibular system and sleep that arises in Sopite syndrome is due to regular, low-amplitude vestibular stimulation for extended periods of time that induce drowsiness, lethargy and reduced attention (Graybiel et al, 1965; Lawson & Mead, 1998). On the other hand, proper vestibular stimulation can be a boon for sleep induction when it is desired. For instance, premature infants given active rocking treatments for 2 weeks showed enhanced quiet sleep compared to matched control infants (Cordero et al. 1986). When adults are swung less than 3" each way in a head to toe direction for two nights, nocturnal sleep latency is reduced (Woodward, et al. 1990). In elderly people, low frequency bed rocking yields significantly greater consolidation of otherwise fractionated sleep patterns (Iber et al. 1989).

While acceleration is the normal stimulus used to stimulate the vestibular system, properly structured and presented sound can be effective under certain circumstances. Complex broadband harmonic sounds are capable of synchronizing large portions of the brain. This allows sound or music to be used as a carrier to deliver stimuli that overlap and interact with targets of the vestibular system. Low frequency low amplitude rumbling noise can drive Sopite responses instead of whole body vibration or rocking, inducing sleep. Binaural beating – structured stereo sounds that synchronize large regions of the cortex – can be used so that the beating frequency oscillates at the rates observed in different stages of sleep, simulating normal neural processes for maintaining sleep and driving the sleeper from one stage to another. Finally, overall arousal can be reduced by auditory facilitated relaxation. This involves the use of calming sounds such as low amplitude pink noise convolved with cardiac and respiratory sound envelopes which decrease in repetition rate across a physiologically appropriate range to lower the listener's heart and breathing rates.

Advanced Brain Technologies TLP SLEEP uses all three methodologies. ABT has developed neurosensory algorithms that use sound to drive sleep-inducing vestibular responses instead of whole body vibration or rocking. Additional algorithms allow us to implement microsecond scale accuracy for fine-grained binaural interactions, and let us use structured noise as a modulatory neural driver. This allows us to use almost any (non-intrusive) music as a carrier to lull the listener to sleep. Ad-hoc clinical testing has demonstrated the effectiveness of our algorithms in inducing sleep by reducing sleep latency and increasing efficiency in subjects range from 1 to 62 years, and has been shown to decrease sleep latency, increase sleep efficiency or both in up to 77% of people with normal binaural hearing in both ears.

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