

Beginning to See the Light

A Fresh Approach
to
Fatigue Management

Executive Summary

Fatigue related accidents across the Mining, Transport, and even Medical industries are costing the community billions of dollars each year. But its not just the financial cost to the community taking its toll, fatigue has other devastating social effects including adverse physical and mental health outcomes.

It seems those in the best position to improve the situation are at a loss to identify new ways to manage fatigue that will keep industry productive and our community safe.

This presentation sheds new light on the benefits of using bright light therapy in the workplace and at home to regulate the circadian rhythms of shift workers.

Two primary brain chemicals melatonin and serotonin are responsible for regulating our circadian rhythms, our sleep and our mood. Because exposure to bright light is the only effective means of shifting the circadian rhythm, its use ensures that night shift workers have the correct brain chemical present at the right time of day or night.

By maintaining better circadian health individuals remain alert and energetic when they need to be. Recent trials in the US have shown that implementing these simple yet effective techniques significantly reduces fatigue related accidents, sleep disorders and circadian related depressions.

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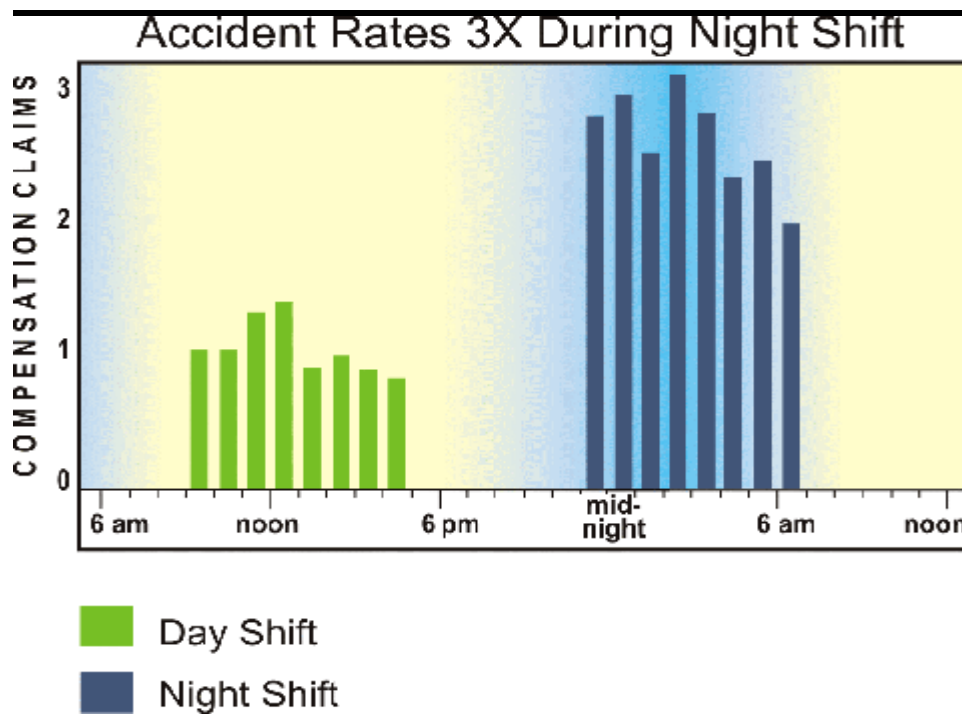
Methods and Technology to resolve shift work problems

Introduction

Shift work and extended working hours are increasing in many industries and organisations in Australia. Bureau of Statistics figures show that at least 2.3 million Australians (just over 1/3 of the workforce) are now working outside regular daytime hours.

According to the Bureau of Statistics more than 500,000 Australians are on rotating shifts, which are acknowledged by researchers and Industry associations as not only the most stressful, but have the most serious health risks.

Working irregular hours has important socioeconomic effects as it leads to an increased risk of accidents, worker impairment and danger to public safety, especially at night. The diagram below illustrates the rise in accident rates at night.



While work outside daytime hours is unavoidable in many industries such as essential services, it's crucial that organisations consider the substantial risks to health and public safety posed by shiftwork and extended hours.

Shiftwork Disrupts your natural Body Clock

Survey studies have shown that shift work and high variability of working hours disrupt our **Circadian Rhythms** resulting in inadequate sleep quantity [1]. This lack of sleep impacts on the shift workers' performance at work, producing symptoms similar to Jetlag. They're less focused on tasks, their concentration and memory slips and they make more mistakes.

Some notable events attributed to operator error during night shift include the grounding of the *Exxon Valdez* (12.30 am), the *Three Mile Island nuclear plant* meltdown (4.00am) and the *Chernobyl Nuclear disaster* (1.30am)

As well as these safety concerns shift work has been associated with several health risks including [2]

- peptic ulcer disease,
- coronary heart disease,
- gastrointestinal disease,
- certain cancers,
- reproductive dysfunction in women
- increasing the likelihood of aggravating an existing medical condition.

Night shiftwork is also associated with an increased perception of mental and physical fatigue typified by insomnia and sleep deprivation.[3]

Shift workers and driving.

One of the most worrying aspects of sleep deprivation is " drowsy driving ". People who are tired and trying to drive are a hazard to both self and others. Road accident statistics show that at least one in six crashes are the result of driver inattention or lapses. In single vehicle accidents on country roads up to one quarter of deaths are the result of the driver falling asleep. In Australia the cost to the community of road crashes involving drowsy driving is estimated to be \$2 billion per year.

Studies from the Centre for Sleep Research in Adelaide have shown that after 17 hours without sleep the level of impairment is equal to a blood alcohol level of 0.05%. After 24 hours without sleep it is the same as a blood alcohol level of 0.10%. Shift-workers have an elevated risk for sleep-related accidents, because at the end of their shift they may have been awake for 16 hours or more. Researchers found up to 30% of shift-workers have had a fatigue related driving mishap in the previous year. Its astonishing that in our society we recognise that it's unacceptable for people to be at work under the influence of alcohol yet we allow people to be at work under the influence of fatigue.

Quality of Life

Employees lives beyond work can be greatly influenced by shift work. The more shift work (particularly night work) and extended working hours that people are exposed to, the greater the effect on the quality of life during off-duty periods.

Rest days may increasingly be experienced as periods of recovery and recuperation from work. Social and domestic activities may still be possible but fatigue, lack of motivation and a general sense of tiredness are all too common.

Increasingly, the courts are laying the blame for accidents and poor health at the feet of employers, who under Occupational Health and Safety (OHS) legislation have a duty of care to employees. Employers must identify the hazards and levels of risk associated with shift work, night work and extended working hours and take action to control them.

It's important to recognise that causes of fatigue are not only work related. In fact about 50% of the time that a person is fatigued can be attributed to the employee's lifestyle choices outside work hours where an employer has no influence. For example, take the employee who decides to spend the day at a friend's BBQ instead of spending that time sleeping. Or the part-time business student who decides to stay up all night studying for an exam before going to work. Employees and employers have a dual duty of care.

What are Circadian Rhythms?

All mammalian creatures have a basic 24-hour daily cycle against which many of their body rhythms operate. These circadian rhythms are regulated by an internal 'body clock' found within the hypothalamus region of the brain. They signal our brain to produce various hormones and neurotransmitters occurring roughly every 24-hours. These rhythms influence every aspect of our lives, from how we sleep and act when we are awake, to how we socialise.

Our circadian rhythms are tied to nature and just as other creatures respond to light induced signals, like the morning light of a new day, so do humans. Morning light triggers our body to produce hormones and neurotransmitters necessary to kick start our system and get going of a morning. These naturally occurring chemicals like Cortisol and Serotonin cause blood pressure to increase and body temperature to rise helping us to wake up and be active.

At sunset the body receives another of nature's cues as it responds to dusk and ultimately the night's darkness. As the sun goes down the body will produce and secrete the hormone melatonin, blood pressure and body temperature will drop as the body prepares for and eventually falls asleep.

In reality circadian rhythms control the timing, quantity and quality of the hormones and neurotransmitters the body produces. These hormones and neurotransmitters are the elements that determine how we feel, our sleep patterns, our appetite, our sex drive and other sleep and mood-related issues. When functioning properly, our circadian rhythms create circadian balance.

An imbalanced circadian rhythm secretes the wrong hormones and neurotransmitter at the wrong time of day, and our bodies suffer from a *Circadian Rhythm Disorder* (CRD). Medical journals report that most mood and sleep disorders have an underlying circadian rhythm disorder.

Zeitgebers: The Body's Way of Synchronising

In order to reconcile the difference between nature's exact twenty-four hour cycle and the internal circadian rhythms we free-run on nature has given us "Zeitgebers", a German word that means "time givers". As modern lifestyles demand more flexibility in schedules man has lost touch with its most valuable Zeitgeber, the sun. Modern lifestyles, work schedules and indoor living has altered the amount of sunlight we receive as well as how we set our schedules.

It used to be that people generally woke up at dawn, worked and spent much of their day outside or near a window and at night-time they read by low levels of light until retiring to bed. For better or worse we don't follow that pattern any longer.

Circadian Rhythm Disorders

Circadian Rhythm disorder means your body is producing hormones, chemicals and neurotransmitters in the wrong amounts and/or at the wrong time of the day. Circadian rhythms stimulate the timing and production of countless hormones and chemicals that affect your sleep and mood. Circadian rhythms permeate almost every aspect of our lives because they influence the chemicals that determine our mood and sleep.

Nature, through its twenty-four hour cycle of day and night, has provided us with a template or a pattern that anticipates what we need to be healthy. Nature has obviously anticipated our needs and when properly synchronised, our bodies respond to nature's external cues. If a person desires optimal health and because the circadian rhythm influences so much of how a person feels or sleeps then they need to manage their circadian rhythm. If a circadian rhythm is out of balance other health aspects will be impacted and out of balance as well.

Insomnia and Depression

Since the circadian rhythm controls the sleep/wake cycle circadian rhythm disorder often results in insomnia. If there is a pattern to the sleep disturbance, i.e., one consistently wakes up or falls asleep at the wrong time or if he/she cannot get to sleep at certain times, it is most likely that his/her circadian rhythm is out of balance.

A recent study conducted by researchers at the University of Wisconsin-Madison [4] confirmed that people who suffer from sleep disorders are very likely to develop symptoms of depression sooner or later. The team also showed that depression risk is directly connected to the severity of sleep disorders. The poorer or shorter the sleep at night the higher the risk of more serious depression symptoms.

Depression is also closely tied to circadian rhythm disorders because almost all depression sufferers have sleep problems and feel worse at a particular time of day. Insomnia disrupts the normal way of life. This can become a vicious circle. You have insomnia and you worry because you can't sleep. As the worry increases, your insomnia escalates, which in turn leads to depression. If you are already depressed, then the depression deepens. If you are recovering from depression, insomnia can cause a relapse.

Research also shows that without sunlight the brain doesn't produce enough *Serotonin*,[5] resulting in the symptoms of depression. When an individual is living in constant darkness as is the case with shiftwork, the darkness signals the brain to overproduce the hibernation hormone, *melatonin*.

Serotonin

Serotonin is a hormone and a neurotransmitter. A chemical necessary for communication between nerve cells. This messenger in the brain affects emotions, behaviour, mood and circadian rhythms. Certain types of depression are sometimes referred to as Serotonin Depression because these mood disorders are typified by imbalances in serotonin. Selective serotonin reuptake inhibitors or SSRI's are commonly prescribed anti-depressants for this condition because they increase the availability of serotonin.

It's important to understand how serotonin works in order to understand how serotonin depression is caused. Serotonin is a monoamine transporter; that is it carries important messages along the neural pathway in the brain. A monoamine is the brain's way of using paper to write a letter or send a message. The monoamine transporter is the brain's postal carrier or mailman. Sometimes the brain doesn't have enough paper to write messages, other times the brain's mailboxes, or receptor sites grab the message too quickly and don't give the paper back like they are supposed to. When an imbalance occurs a mood, energy or cognitive problem results. This is why serotonin is closely associated with depression.

Melatonin & Depression

Melatonin is an important night-time hormone associated with sleep and regeneration. However, excessive levels or daytime melatonin can cause depressive disorders. Medical research confirms the relationship between melatonin and mood disorders.[6]

Melatonin is normally released by the pineal gland in the evening as sunlight is diminishing. Melatonin causes us to feel tired and withdraw. This helps us to sleep, but if we have to be awake when melatonin is in our system, we become lethargic, disoriented, irritable and moody. This explains why shift work and jet lag can be so debilitating and why depression rates are highest in darker climates. Almost everyone with a mood disorder suffers worse in the winter because of reduced light and excess melatonin in his or her system.

Other factors can cause our bodies to produce melatonin into the day. Some causes such as trauma, stress, injury, age or lack of light will shift your body's timing or release of melatonin. This shift can create excessive levels during the day and not enough melatonin at night.

Symptoms commonly associated with a melatonin imbalance include

- Tiredness or lethargy during the day,
- Social or physical withdrawal,
- Irritability excessive sleepiness or insomnia.

Specialised bright light suppresses melatonin and increases the production of serotonin. [7]

Using Light to Balance the Circadian Rhythm

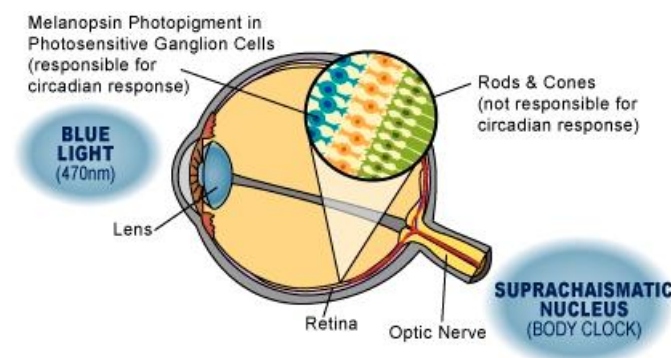
The most helpful advice for fatigue management of shift workers is to receive a consistent schedule of light, regardless of the shift schedule. For example, if someone must shift schedules every few days, the best strategy would be to receive bright light before going on and during the shift.

New research [8] shows that receiving a 30-minute burst of light before shift and then 15 minutes of light every 2 – 3 hours during shift not only increases alertness and performance, but shifts the body clock as well.

Exposure to specialised bright light is the only effective means of shifting circadian rhythms back to their normal pattern. Researchers [7] now know that our brains respond best to a narrow band of blue light (460-480nm) and that this particular wavelength is twice as effective as white light in eliciting a circadian response.

How does it Work?

In 2001 Dr. George Brainard's team at Thomas Jefferson Medical University identified photosensitive cells in the retina of the human eye that absorb light in the 470 nm range (blue). These cells are responsible for reacting to light and controlling the production of melatonin and serotonin. [9]



When bright light enters the eye a chemical messenger produced in the retina called Melanopsin activates a nerve that connects the retina to a key point in the Hypothalamus region of the brain known as the Suprachiasmatic Nucleus (SCN) or body clock.

Once activated the Hypothalamus sends a signal to the Pineal gland. The pineal gland immediately suppresses the withdrawal hormone Melatonin and stimulates the production of the active hormone Serotonin.

As Serotonin is released you become more active, energetic and alert. This action Improves concentration and motivation.

Shift workers can find considerable relief by using 470nm blue light to suppress melatonin while working at night. A 10 to 15 minute burst of light is sufficient to suppress melatonin for approximately three hours at a time. One only needs to combine specialised 470nm blue light with regular breaks 2-3 times during the night to remain alert and help shift the circadian rhythm.

Bright light should not be used any later than 2 hours before the end of shift as this will suppress the melatonin required to induce restful sleep and maintain a constant circadian rhythm.

Going on Shift night shift

Receiving a 30-minute burst of light before shift and then 15 minutes of light every 2 – 3 hours during shift not only increases alertness and performance, but shifts the body clock as well. Within three days, the body clock will have shifted to a night shift schedule. Taking time-release melatonin upon arriving home may accelerate shifting the body clock.[10] After the second day melatonin should not be necessary and the body clock will have adapted to the new schedule. While working night shift it is important to:

- go straight home,
- wear sunglasses to avoid any bright light and go straight home (sunlight at this time may make it difficult to sleep),
- make sure the room where you sleep is darkened and that all distractions, phone calls and lights are screened out.
- Make sure people know you should not be disturbed.
- Keep the bedroom cool.
- Avoid caffeine, sleeping pills, alcohol or nicotine before going to bed.

Coming Off night Shift and returning to a day schedule

When coming off shift, and returning to a day schedule one should NOT wear sunglasses, as it is now important to receive bright morning light. After arriving at home, the shift worker should use 470nm light in the morning for approximately 30 minutes and he/she should wait at least three hours before going to sleep. After awakening, he/she may wish to use time-release (exogenous) melatonin in the early evening (4-7pm) to accelerate his/her body clock shift.

Accelerating circadian shifting with melatonin

Using melatonin in conjunction with bright light can accelerate shifting the body clock. A small dosage of melatonin (1 to 3 mg) taken approximately 12 hours after bright light is received will help move the body clock as much as four to six hours each day, in either direction.

Shifting from Day Schedule to Night

Because the circadian shift can be greater with melatonin, it may be easier to accelerate the body clock to the desired wake/sleep time. For example, one could shift his body clock from morning to evening by using the following schedule:

Day	Bright Light	Melatonin
1	6:00am	6:00pm
2	2:00am	2:00pm
3	10:00pm	8:00am

After the third day, one could be receiving bright light at the desired wake time, and not have to take any more melatonin.

Shifting from Night to Day Schedule

The schedule for shifting from night to day is the reverse of the previous schedule, but with one exception. It is important to avoid bright light before each light session.

Day	Bright Light	Melatonin
1	6:00pm	6:00am
2	2:00pm	2:00am
3	10:00am	8:00pm

Once the desired shift is achieved, light should be received at the regular, new wake-up time.

Cautions With (Exogenous) Melatonin

Since most of the effort in shifting circadian rhythms requires the suppression of melatonin, light is the most effective means of shifting rhythms. Therefore, melatonin should not be considered solely effective in shifting the body clock.

One may want to wait a few hours after waking in the afternoon or evening before taking melatonin as it may cause drowsiness. Melatonin should not be taken if the person needs to drive or use heavy equipment. It is also very important to avoid any bright light while melatonin is active in the system. Melatonin should not be taken when pregnant.

Under Australian law administered by the TGA melatonin is a controlled substance and only available after consultation with your doctor.

Apollo Health

Apollo Health has been the leading researcher and manufacturer of world-class products that allow people to overcome sleep and depressive mood disorders by restoring balance to their circadian rhythm.

For nearly 20 years Apollo has helped hundreds of thousands of people manage their body clocks. Apollo's technology has been published in nearly 100 research articles in peer-reviewed medical journals including

- Science
- Biological Psychiatry
- Journal of Biological Rhythms
- Journal of Depression and Anxiety
- Journal of Sleep
- Archives of General Psychiatry
- Journal of Affective disorders
- Chronobiology International

Apollo has participated with the National Institute of Health and most leading universities in researching and finding solutions to treating conditions such as, Seasonal Affective Disorder, Depression, insomnia and other mood & sleep disorders.

Apollo Health's light therapy products are distributed by Nadian Pty Ltd. ABN 93003561715 and have been approved for sale by the Therapeutic Goods Administration (TGA). Enquiries can be directed to ian@lighttherapy.com.au or ph +61 2 66723065 or visit www.lighttherapy.com.au

References:

- [1] Diane B Boivin, Genevieve M. Tremblay, Francine O. James Working on atypical schedules
Sleep Medicine 8 (2007) 578-589
- [2] Knutsson A. Health disorders of shift workers. Occup Med (Lond) 2003;53:103–8.
- [3] The impact of night work on subjective reports of well-being: an exploratory study of health care workers from five nations. Rev Saude Publica 2004;38(Suppl):26–31.
- [4] Paul E. Peppard, PhD; Mariana Szklo-Coxe, PhD; K. Mae Hla, MD; Terry Young, PhD
Longitudinal Association of Sleep-Related Breathing Disorder and Depression.
Arch Intern Med. 2006;166:1709-1715.
- [5] G. Lambert, C. Reid, D. Kaye, G. Jennings, M. Esler
Effect of sunlight and season on serotonin turnover in the brain. The Lancet, Volume 360, Issue 9348, Pages 1840-1842
- [6] Alfred J. Lewy, MD, PhD; Vance K. Bauer, MA; Neil L. Cutler, BA; Robert L. Sack, MD; Saeeduddin Ahmed, MD; Katherine H. Thomas, MD; Mary L. Blood, MS; Jeanne M. Latham Jackson, MD Morning vs Evening Light Treatment of Patients With Winter Depression Archives of General Psychiatry - October 1998
- [7] Steven W. Lockley, George C. Brainard, Charles A. Czeisler. High Sensitivity of the Human Circadian Melatonin System to Resetting by Short Wavelength Light. The Journal of Clinical Endocrinology & Metabolism 88(9):4502–4505 doi: 10.1210/jc.2003-030570
- [8] Lockley, S.W., Evans, E.E., Scheer, F.A.J.L., Brainard, G.C., Czeisler, C.A., and Aeschbach, D. (2006). Short-wavelength sensitivity for the direct effects of light on alertness, vigilance, and the waking electroencephalogram in humans. Sleep 29, 161–168
- [9] Brainard, G.C., Hanifin, J.P., Greeson, J.M., Byrne, B., Glickman, G., Gerner, E., and Rollag, M.D. (2001). Action spectrum for melatonin regulation in humans: Evidence for a novel circadian photoreceptor. J. Neurosci. 21, 6405–6412.
- [10] Crowley SJ, Lee C, Tseng CY, Fogg LF, Eastman CI. Combinations of bright light, scheduled dark, sunglasses, and melatonin to facilitate circadian entrainment to night shift work. J Biol Rhythms 2003;18:513-23.
- [11] Rabiul Ahasan , John Lewko, Donna Campbell, and Alan Salmoni,
Adaptation to night shifts and synchronisation processes of night workers
Journal of Physiological Anthropology and Applied human science.
- [12] L. C. Lack and H. R. Wright Chronobiology of sleep in humans.
Cell. Mol. Life Sci. 64 (2007) 1205 – 1215



