Chapter Two
Getting Less Sleep Than We Should

Long ago, a person was said to be 'burning the midnight oil' if they had to use an oil lamp to light their work area after natural light had diminished. In modern times, many a workplace is illuminated through the night until daylight once again fills the sky. The 24-hour society is such that businesses and workplaces invest enormous resources into buildings, machinery and rolling stock. The rolling stock on a mine site would normally comprise multi-million-dollar pieces of machinery such as diggers, shovels, haul trucks, water carts, scrapers, graders, service trucks and light vehicles. One haul truck can cost between $1-4 million and some of the larger operations can have up to 180 haul trucks.

As long as a piece of machinery is sitting idle, the workplace is not fully utilizing its worth. Thus, 24-hour operations are now the norm, and most mines will utilise two 12-hour shifts as opposed to the past 8-hour rotating rosters (three per day). This is a simple example of one of many workplaces now working around the clock, and it is unlikely that a change back to not working nights will be financially viable for most organizations now working 24-hour cycles.

Along with the 24-hour workplace, humans are now being entertained much later into the nights than ever before. Hotels, nightclubs, casinos, and a plethora of shopping centres and entertainment venues are now open 24 hours. Add to this, television and other forms of media such as internet, and you have a society that often either forgets to go to bed at the right time or simply doesn't plan a good night of sleep. Most people are totally unaware of their sleep requirements and indeed, their circadian rhythms.

In the previous chapter, we learnt that the metabolic product Ad is metabolised in the brain while we sleep. It was also suggested that it takes approximately one hour to metabolise the Ad from two hours of being awake. Quite simply, this fits the concept of the sixteen-hour day, followed by an eight-hour sleep. The suggestion of an eight-hour sleep has been around for many a decade. In fact, most journal articles, websites and conference presentation will recommend between seven and nine hours of sleep for a normal, healthy adult.

In 2015, results were published of a 'Joint consensus statement of the American Academy of Sleep Medicine and Sleep Research Society on the recommended amount of sleep for a healthy adult'[20]. This very large group of some of the best sleep and fatigue scientists in the world gathered to discuss and vote on what they believed, based on the available literature, to be the recommended range of sleep for a healthy adult. I have been lucky enough to have met and listened to some of these amazingly knowledgeable people.

Their literature review commenced with finding 5,314 publications, then reducing the number of these publications because they were not related directly to sleep. The final number

for panel review was 311 publications. After three rounds of voting, which included discussion of the publication findings at a conference, a summary of the voting was developed. The group reached the following conclusions:

- Consensus that six hours of sleep or less was inappropriate to support optimal health
- Consensus that seven to nine hours of sleep were appropriate to support optimal health
- Consensus that the appropriateness of nine or more hours of sleep on optimal health could not be ascertained with certainty
- Consensus could not be reached regarding the appropriateness of sleep durations in the six-to-seven-hour range, but the median vote indicated this duration was in the inappropriate range

In 2019, I delivered face-to-face training to over 5,200 people at workplaces and a further 3,300 (approximately) attendees at various conferences in Australia. When asked the question "Who here gets seven or more hours of sleep?", roughly 20% will say they do by a show of hands. Another 20% say they get less than 6 hours of sleep, while the remaining majority of approximately 60%, will state that 6 hours of sleep is the norm for them. These are approximations from interactions with attendees of fatigue/sleep awareness sessions only and should not be used as statistics.

In most cases, this has little to do with their work, and more to do with their lifestyle. A vast number of Australians (and other nationalities around the world) are under slept. Globally, people have probably been under slept for a long time, but it is only

more recently that this has been researched. Some people wear short sleep as a badge of honour, while others are desperate for more sleep but don't know how to get it. I often receive sincere requests from people who want help getting more sleep. This indicates to me that people have almost forgotten how to sleep well, and some are desperate for more.

Sleep debt.

The theory of Ad metabolism allows us to better understand what a sleep debt is. Sleep debts are often realised during afternoon circadian low points or when driving some distance in a vehicle. Especially in a sedentary position! It can be a feeling of sleepiness, including trouble keeping the eyes open and not being able to focus on any specific task for too long. When this occurs, most people simply think they didn't get enough sleep the night before. Although this is often the case, most don't realise that the sleep drive they are experiencing is the brain attempting to go to sleep to reduce the build-up of Ad, or to pay back the sleep debt. A haul truck driver who had several fatigue events captured by a 'seeing-eye-machine' in his truck, was gobsmacked by the notion that his falling asleep at the wheel was most likely the brain attempting to catch up on his sleep restriction, after averaging five hours of sleep a night for the past four nights on a camping trip. So, what exactly is a sleep debt?

When we sleep for less time than we should, some Ad will be left behind and not metabolised and recycled back into fuel. For example, if we have a normal day but stay up late to watch television, play games or spend hours on social media, we can be awake for as long as twenty hours. What normally happens in this case is that you go to bed around midnight but still need to

wake up early, say around 5 am for work. You have only had the opportunity to get five hours of sleep, which will only give you 10 hours of performance. Plus, you will not have recycled all of the Ad and some will be left behind.

Starting the day with a lot of Ad in the brain is not that troublesome, although you will generally wake feeling tired. However, when you then add a further eight-hours awake (in the example of the 5 am alarm, through to 1 pm), your brain will now be the equivalent as it would be for an 18-hour day. At 1 pm, your brain is now ready to produce a sleep drive due to the large amount of Ad and low levels of the fuel ATP in the brain. Add to this, the earlier mentioned 'post-lunch dip', where people often get drowsy due to the lowering of core body temperature after lunch, and you have a sleep debt recipe for disaster. Basically, '*the brain wants to sleep to get more fuel to make it through the day*'.

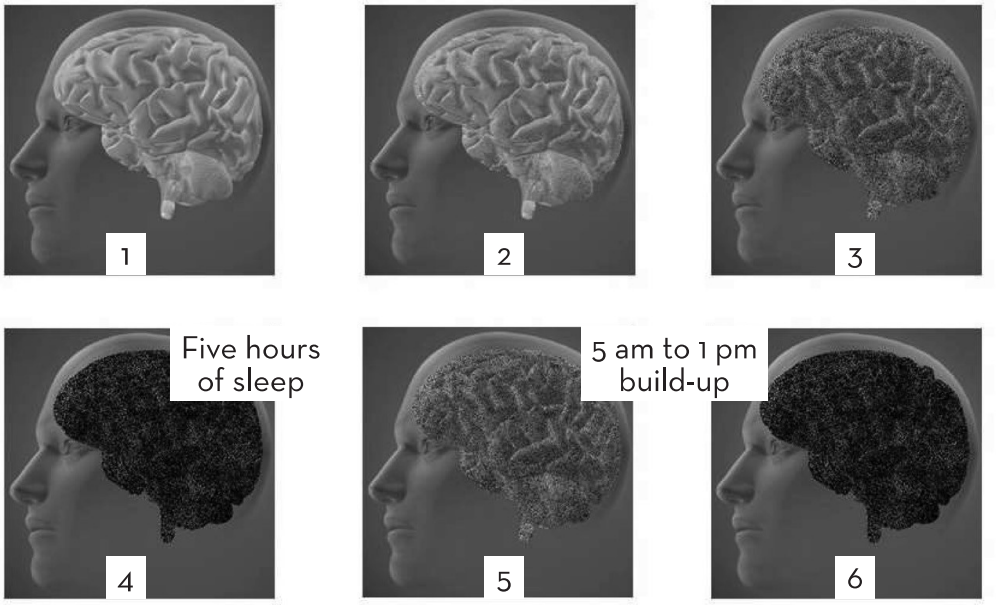


Figure 9: *Build-up of sleep debt using the adenosine model over a 20-hour waking day.*

The sleepiness caused by the sleep debt makes us less efficient at work, less safe and with reduced motivation and lowered moods. Figure 9 above represents how a sleep debt is built from inadequate opportunities to recycle Ad within the brain. It is an extension from Figure 4 in chapter one.

The first three images show the normal build-up of Ad over a 16-hour day, from 0 hours awake – to 8 hours awake, then 16 hours awake. The fourth image shows the high level of Ad from being awake for 20 hours. The fifth image illustrates that only a portion of the Ad is removed or metabolised due to obtaining only 5 hours of sleep. Accordingly, it wakes at 5 am with a large amount of Ad build up remaining.

The final image (number six) shows how the Ad has built to a high level again by 1 pm, after being awake a further 8 hours. This, together with the drop in core body temperature after lunch, will cause a sleep drive to recycle more brain fuel. The sleep drive will be most profound when the person with the sleep debt is in a sedentary position. As Mahowold and Schenck[21] term it, *"Boring lectures, dimly lit rooms, heavy meals or long automobile drives do not cause sleepiness, they simply unmask it"*. This doesn't suggest that good sleep is all you need to consider when you do long drives or extra-long shifts. It simply means that if you have a sleep debt, being in a sedentary position can bring on sleep onset.

Sleep architecture changes in short sleep

In chapter one, the architecture of sleep stages and cycles was illustrated and discussed. The diagram, which is repeated below in Figure 10, shows how most of the deep sleep is obtained in the first half of the night, while the REM sleep is obtained mainly in

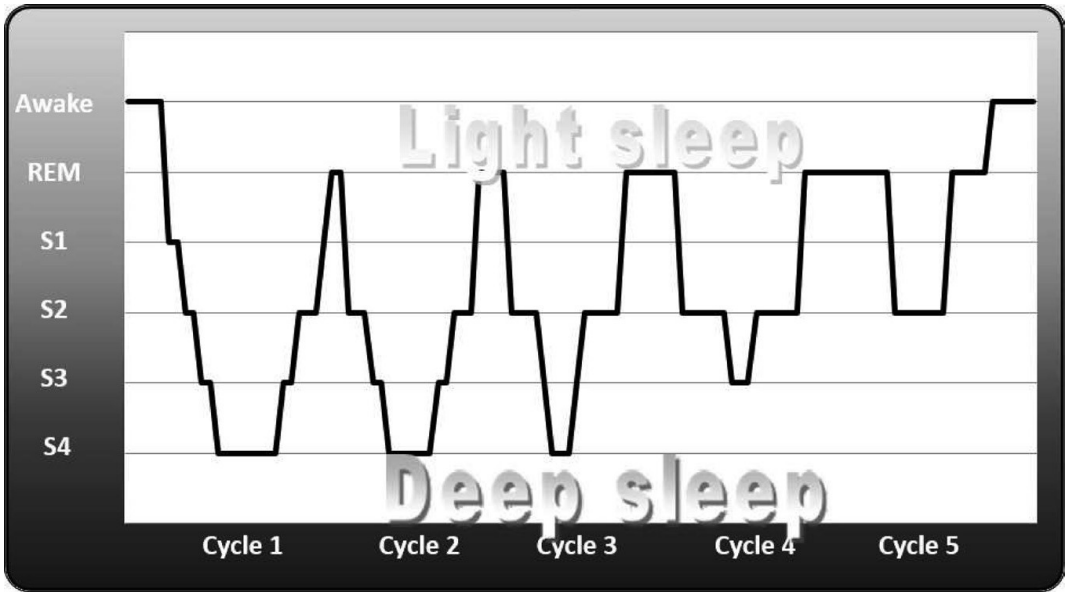
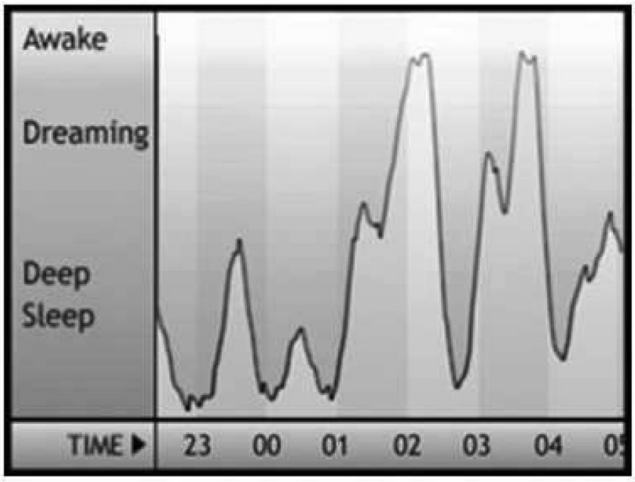


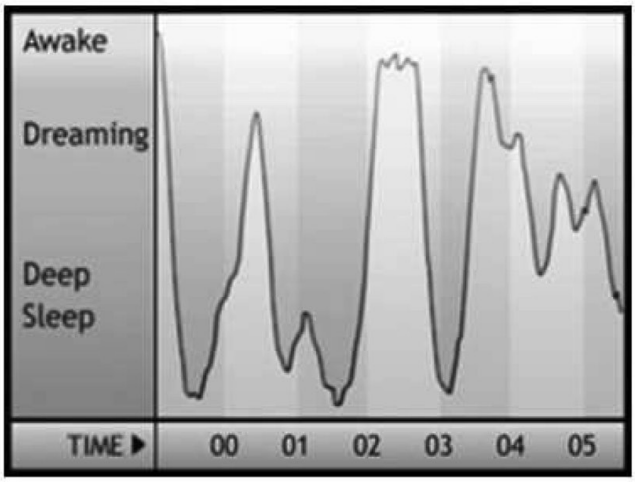
Figure 10: *Sleep stages and cycles in a 7.5-hour sleep.*

the last half of the night. A total of approximately two hours of deep sleep and two hours of REM sleep is required to maintain health, wellness and safety.

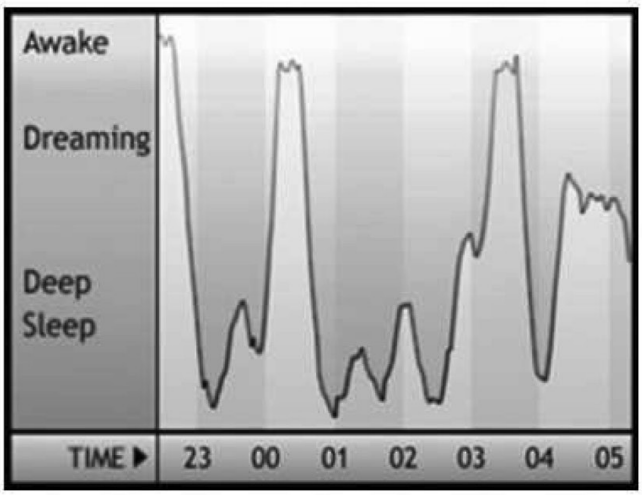
The above sleep stages and cycles are dependent upon a person obtaining around 7.5 hours of sleep, which is 5, 90-minute cycles. The cycles tend to change when an individual obtains less than the appropriate sleep. The graphs below are recordings of sleep as measured with a mobile phone sleep app. It should be stated that such apps are less than appropriate for plotting highly accurate sleep data. Nonetheless, they are cheap and allow a simple way of measuring sleep and the data often encourages people to try to get more sleep. Further, they are more reliable than subjective assessments of sleep, as many people usually underestimate their sleep. I recommend using phone apps within fatigue management training to encourage people to measure and get interested in their own sleep. Plotted sleep graphs from



Sleep night 1: Note the large amount of deep sleep but a lack of REM sleep (shown in the graph as 'dreaming'). It also shows being awake twice through the night for periods of around 15 minutes each.



Sleep night 2: The graph is showing what is known as 'REM rebound', whereby the brain attempts to get REM sleep early in the night to compensate for the lack of it the previous night. This decreases deep sleep opportunity.



Sleep night 3: This is similar to the first sleep, showing considerable deep sleep and only a small component of REM sleep. The only component of REM sleep is within the final cycle of sleep.

Figure 11: *Six-hour sleep with sleep stage anomalies.*

reduced sleep, such as those shown in Figure 11, have also been recorded in research, and similar outcomes as those below have been found.

There was a total of six graphs provided, which repeated through cycles of mainly deep sleep on one night, followed by mainly REM sleep on the next night, and so on. There was not a single night of six-hours of sleep that indicated close to the right amount of both deep sleep and REM sleep. How this would affect the man is discussed next.

The sleep is of a male aged around 55 years, with obstructive sleep apnoea, a condition whereby the sufferer has breathing cessations through the sleep period. It will be discussed fully in the next chapter. His apnoea is controlled well with continuous positive airway pressure (CPAP) therapy. He attempts, like so many others, to get around six hours of sleep per night and sometimes catches up a little on weekends. He goes to bed around 10.30 pm – 11 pm and wakes around 5 am – 5.30 am for work, Monday to Friday. When he first showed me the graphs, it became suddenly clear that sleep cycles can become disorganised due to limited sleep opportunity.

The first graph shows that almost 2 hours of deep sleep is obtained in the first 3 hours. After 3 hours he moves towards REM sleep, indicated on the left axis of the graph with the word 'dreaming'. He may have obtained 10-15 minutes of REM sleep at this point. He then awakens around 2 am for perhaps 15 minutes and goes back into deep sleep. Around 3 am he gets another brief period of REM sleep and awakens again, for a further 15 minutes. Following his re-entry to deep sleep again, he manages a very brief amount of REM sleep before waking up for work.