Whilst our bodies strive to fit in with the day and night, the modern social world imposes its own demands on our internal clock which can cause disruptions to our natural sleep patterns. A recent study at the Universities of Surrey and Texas demonstrated that mistimed sleep can cause significant disruption at the genetic level to our internal rhythms.

A little bit about biological rhythms

All animals live in a world dependent on two of nature’s ‘clocks’: the biological and the solar. The biological clock presents itself in cycles of behaviour, physiology, and gene expression approximating the 24 hour day and are thus known as circadian rhythms (‘circa’ about, ‘dies’ day; Latin). The solar clock is the light-dark cycle we are all familiar with and with which we synchronise our sleeping and eating. When these two clocks align we get well timed sleep and our associated internal rhythms synchronise, however mismatch between the clocks is known to significantly affect an individual’s hormonal cycles and mental function such as alertness. In general, proper sleep cycles underlie good health and strong internal synchronisation.

Until recently the biological and solar clocks have sufficed in the lives of humans. However, the development of the modern world has introduced a third ‘social’ clock. This is any factor relating to society which causes us to change our sleep cycles. For example, shift-workers such as nurses work long and changing hours out of sync with the biological and solar clocks. This means no routine sleeping pattern is attainable. Another modern instance is that of jet-lag: when we cross time-zones we gain or lose hours which effectively shift our normal sleep time. I’m sure many of us have experienced the effects! Overall this means that the effect of living in the modern world pushes and pulls us against the natural rhythms inside us all.

The human circadian system starts in a small brain region behind the eyes known as the ‘supra-chiasmatic nucleus’ which synchronises the rhythms of the brain and the rest of the body via neural, hormonal, and behavioural changes. Circadian rhythms operate at every level from gene expression, through physiology, to behaviour. However, whilst it is known that sleep disruption affects behaviour and physiology, it was unknown if this is true at the genetic level.

So what’s new?

The current work addressed this by measuring the effect of sleep disruption on the expression of a wide range of genes to assess what processes they relate to. They used a ‘forced desynchrony’ method which involved measuring participants natural sleep patterns via activity monitors and sleep diaries for a week before adjusting their routines to a 28 hour day. This led to an approximate increase of four hours each day to their natural cycles, pushing sleep onset four hours later compared to the
natural world. The study took blood measurements to assess the rhythms of a circadian hormone called melatonin, which normally peaks during the period when you are usually asleep. They then used samples taken when sleep did or did not align with this peak of melatonin to compare levels of gene expression between normal and mistimed sleep. They found that total sleep time decreased as sleep rhythms fell out of time with the melatonin signal. They found that when sleeping normally roughly 6% of the measured genes were expressed rhythmically, dropping to only 1% as sleeping was shifted. These were largely involved in switching on and off other genes. These genes were also expressed more than usual, whereas genes involved in metabolism were expressed less. This suggests that not only does disrupted sleep result in genes being expressed out of sync with the body, but that it actually changes the proportions of those which are expressed. They then compared results of this study to one of their previous studies which looked specifically at reduced rather than mistimed sleep on gene expression. They found that both forms of poor sleep lead to disrupted gene expression, but relating to quite different processes. Taken together, these results demonstrate that poor sleep (be it at the wrong time or not for long enough) have significant impact on the expression of a wide range of genes.

Further understanding the impact and mechanisms of sleep and circadian disruption can help us to create interventions for those at risk of developing social clock-related issues, such as shift workers and those who have to cross time-zones frequently. It also will help to develop aids for those with sleep disorders and to identify the potential markers that lead to such problems.