Sleep Deprivation and its Link to Neurodegenerative Diseases: Causal or a Consequence?

The importance of sleep is often understated and the number of people who prioritise sleep is falling dramatically in this modern era. Sleep deprivation has become a common issue in more developed countries, which can be evidenced by the fact that people in Western countries are reportedly sleeping on average only 6.8 hours per night, which is 1.5 hours less than a century ago (Nagai et al, 2010). The consequences of people repeatedly deciding to sacrifice their sleep is becoming more evident as research within this area has advanced in recent years.

Disruption to sleeping patterns has been shown to make people more susceptible to certain diseases and general health issues. For example, a significant link has been made between sleep deprivation and cancer. In 2007, the International Agency for Research on Cancer (IARC) classified shift work involving circadian disruption as a probable human carcinogen (Erren et al, 2010). Also, evidence has demonstrated that in the Spring, when we lose an hour of sleep, there is a subsequent 24% increase in heart attacks that can be seen on the following day. However, in the Autumn, when we gain an hour of sleep, we can see a 21% reduction in heart attacks (Sandhu et al, 2014). Moreover, insomnia and sleeping time are associated with an increased risk of coronary heart disease, hypertension, and heart failure (Terzaghi et al, 2020).

In terms of the link between sleep deprivation and neurodegenerative diseases, an analysis estimated that as many as 15% of cases of Alzheimer's dementia are attributable to poor sleep. Studies have found that even a single night of sleep deprivation can increase the amount of beta-amyloid in the brain (Suni, 2020). Beta-amyloid is a metabolic waste product that's found in the fluid between brain cells. A build-up of this has been closely linked to impaired brain function and Alzheimer's disease. In Alzheimer's disease, beta-amyloid clumps together, forming amyloid plaques, which disrupt the transmission of information between neurons. Other studies in mice have discovered that sleep plays a role in removing beta-amyloid out of the brain and that a lack of sleep can elevate brain beta-amyloid levels (NIH, 2018). However, there may be some doubt over whether humans experience this and the use of animal studies in support of this idea can be criticised on the basis that animals are far less cognitively complex than humans and so generalisations cannot be made.

It has been shown that sleep disturbances precede the diagnosis of Alzheimer's Disease and poor sleep quality in healthy people has been linked to cognitive impairment. Lim et al discovered that people with high levels of sleep disturbance have a 1.5 times higher risk of developing Alzheimer's disease in a 6-year follow-up period. Benedict et al conducted a 40-year study, that consisted of 1,574 men aged 50 and over, and found that people with sleep disturbance had a 51% increase in the risk of developing Alzheimer's disease (Lloret et al, 2020).

Further research conducted within this area has found that the affected brain structures in people suffering with sleep disturbance coincide with vulnerable areas in Alzheimer's disease. Lower grey matter volume in the hippocampus, precuneus, amygdala and cingulate gyrus as well as a higher degree of cortical atrophy have been described in cognitively unimpaired insomnia patients. These findings are supported by other studies. For example, in a recent study, looking at cognitively unimpaired adults aged between 45 and 75, it was found that insomnia patients presented with a decrease in grey matter volume in Alzheimer's related areas, that matched with findings from other studies (Lloret et al, 2020). This supports that there may be a causal relationship between sleep deprivation and Alzheimer's Disease.

However, neurodegenerative diseases could be caused by a multitude of factors and if sleep deprivation is a factor, it may be insignificant in comparison to other factors. Sleep deprivation is only one of the environmental factors to be considered when attempting to determine the cause of these diseases. Since the pathogenesis of many of these diseases remains unknown, a range of environmental factors must be considered. Potential risk factors for neurodegenerative diseases include certain genetic characteristics as well as increasing age. Moreover, factors like gender, poor education, smoking and more must be considered when trying to determine the cause of these diseases (Brown et al, 2005).

Despite the evidence to suggest that insomnia is a cause of neurodegenerative diseases, there are studies that would not support this conclusion. For example, anti-dementia drugs may themselves disturb the sleep-wake cycle. Memantine is used for the treatment of moderate or severe Alzheimer's disease (Jung et al, 2012). It works by blocking the effects of an excessive amount of a chemical in the brain called glutamate (NHS Choices,

2019). However, a potential side effect is wake promotion and insomnia in Alzheimer's patients. A few studies showed that memantine increases total awake time and reduced total sleep time (Jung et al, 2012). This suggests that sleep deprivation is an indirect consequence of developing Alzheimer's disease and that there is insufficient evidence to establish a direct correlation. This is because drugs like Memantine, taken by sufferers of Alzheimer's may be responsible for the sleep disturbances that commonly accompany other symptoms of the disease.

Moreover, older people are generally more susceptible to neurodegenerative diseases as ageing is the primary risk factor for conditions including Alzheimer's and Parkinson's disease. In fact, one in ten individuals aged 65 or over has Alzheimer's disease and the prevalence of this disease continues to increase with increasing age (Hou et al, 2019). Not only are older people more susceptible to these diseases, but they are also more susceptible to sleep problems, like insomnia. It has been shown that 75% of older adults experience symptoms of insomnia (Nguyen et al, 2019). Therefore, a potential argument that could be put forward is that the problems of sleep deprivation and the development of neurodegenerative diseases are not directly linked but are in fact both affected by the variable of age. The fact that they coincide with each other in many instances does not necessarily support a direct link. The correlational nature of research in this area means that extraneous multiple factors could be involved in the development of either neurodegenerative diseases or sleep problems, like insomnia.

The secretion of melatonin decreases in Alzheimer's disease and this decrease has been put forward as an explanation for disruption to the circadian cycle, decrease in sleep efficiency and impaired cognitive function seen in Alzheimer's patients (P. Cardinali, 2010). Melatonin is a hormone that occurs naturally in your body and helps to control your sleep patterns. It can be used to treat sleep problems in people aged 55 and over. Melatonin acts on receptors in your body to encourage sleep (nhs.uk, 2019). Therefore, it could be concluded that the decreased secretion of melatonin in Alzheimer's patients could explain the sleep disturbances that accompany the disease. This supports the argument that sleep disturbances are a consequence of neurodegenerative diseases.

In conclusion, there are several studies that have contributed to establishing a causal link between sleep disturbances and neurodegenerative diseases. However, these studies can be criticised for their findings being purely correlational. Correlations mean that cause and effect cannot be established as you can't be certain as to whether the variable of sleep deprivation is having a direct effect on an individual developing a neurodegenerative disease, or whether other extraneous variables are more significant contributors.

There is support for the idea that sleep disturbances are a consequence of neurodegenerative diseases as they commonly coincide with diseases like dementia. These sleep disturbances are not necessarily present before the sufferer develops dementia. In addition, the fact that melatonin secretion decreases in Alzheimer sufferers also suggests that sleep deprivation is a consequence of these diseases as melatonin plays a role in regulating the sleep-wake cycle. However, melatonin levels naturally decrease with age and so this may not necessarily just relate to sufferers of neurodegenerative diseases but the elderly people in general. Insomnia does become more prevalent with age and this factor may help to explain why.

After conducting my research and evaluating the available evidence, I believe that to make a definitive conclusion, more research needs to be conducted in this area. The fact that sleep disruption commonly coincides with the diagnosis of a neurodegenerative disease does seem to suggest that sleep disturbances are a consequence of these diseases. However, it could be argued that sleep disruption exacerbates cognitive impairment and is potentially a contributor to, or cause of, neurodegenerative diseases.

This is a vitally important area of research. Worldwide, around 50 million people have dementia and each year there are nearly 10 million new cases. The total number of people with dementia is projected to reach 82 million in 2030 and 152 million in 2050 (World Health Organisation, 2020). More resources must be dedicated to this area of research to enable the development of new preventative therapies as currently, available treatments can only slow the progression of dementia. There is currently no cure for dementia (NHS Choices, 2019).

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