Sleep and the Gut Microbiome

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Sleep and health

Sleep is intrinsically linked to the functioning of the immune system, physiological processes (e.g. metabolism) and multiple body systems (such as gastrointestinal and cardiovascular).

Despite the continued emphasis on the importance of sleep for health, one third of adults report less than seven hours of sleep per night. Among the estimated 20% of the working population who are employed in shift work, sleep disorders such as insomnia are widespread.[1–3] In addition, other common lifestyle factors such as frequent long-haul travel can also wreak havoc on sleep.

Indeed, research has demonstrated that sleep deprivation, poor sleep quality and/or sleep timing underpins the pathophysiological basis of disease, leading to profound short and long-term effects in otherwise healthy individuals. Short-term effects include such things as emotional distress, mood changes and increased stress. Longer-term effects include hypertension, weight-related issues and type-2 diabetes.

Circadian rhythms

The rotation of the Earth leads to light-dark cycles over a 24-hr period and humans have synchronised to this by developing circadian rhythms. This mechanism dictates feeding, temperature, sleep-wake, metabolic homeostasis and hormonal changes in a coordinated manner.[4] Our circadian rhythm is orchestrated by the brain's 'light master clock', which resides in a small region of the hypothalamus. This in turn synchronises all of the peripheral clocks, which exist in virtually every individual cell in the human body.

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Circadian rhythms and the gut

Not only is the gastrointestinal tract the largest endocrine organ in the human body, it also harbours 70% of the immune system, which is tightly regulated by our circadian rhythm. In fact, the number of immune cells and their activity fluctuates over the course of a day.[5] This helps to maximise immune defence when pathogen exposure is heightened and to lower the response when pathogen exposure is less.[6]

Circadian rhythms and the gut microbiota

In recent years, there has been considerable interest in the gut microbiome and its implications in sleep regulation. Often referred to as the 'second brain', the gut microbiome and its metabolites are a hub of activity, involved in the control of critical processes. Emerging research now suggests that the disruption induced by lack of quality or quantity of sleep could lead to misalignment of circadian rhythms, instigate an unfavourable shift in the gut microbiome, drive a dysbiotic microbial environment, and promote risk of metabolic disturbances and chronic health conditions such as CVD, metabolic syndrome and type-2 diabetes.

Despite the fact that the gut microbiome does not experience light-dark cycles, it is subject to changes in daily occurrences including nutrient availability, temperature, hormonal changes (e.g. melatonin, cortisol) and metabolite production (e.g. SCFAs, secondary bile acids, vitamins, neurotransmitters). Collectively, this results in rhythmic changes in microbial communities, which alters the shape of the microbial landscape over the course of a 24-hr period.

Consequently, the intestinal epithelium is exposed to different microbes and their metabolites at different times throughout this rhythmic cycle, which drives changes in host circadian clock genes located in cells lining the gastrointestinal tract. Furthermore, animal studies have also suggested that the gut microbiome influences the regulatory network of clock genes, and vice versa.[7] Notably, another important aspect is the emerging research into chrono-nutrition, which encompasses eating behaviour in relation to timing, frequency, and regularity.

Sleep research

Sleep is an emerging area of research in the context of the gut microbiome, with conflicting outcomes to date. For example, a study of two nights of partial sleep deprivation or normal sleep led to alterations in gut microbial composition (e.g. increased Firmicutes:Bacteroidetes ratio). No effect on beta-diversity or SCFAs were observed, though reduced insulin sensitivity was observed in partial vs. normal sleep.[8] Dissimilarly, a study involving longer periods of sleep deprivation did not appear to induce overt alterations in the richness of composition of the gut microbiome.[9] Equally, another study concluded better sleep quality was associated with improved performance on cognitive tasks.[10]

Summary

As understanding of the relationship between circadian rhythms, the gut microbiome and its implications in sleep health deepens, microbiome-based therapeutics could pave the way for manipulation of host clock genes as a way of correcting the misalignment or dysregulation underpinning the pathophysiological basis of disease.

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