

*Invited lecture/Review*

The Impact of Sleep Deprivation on Physical Activity

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Citation: Vrbinc KN, Vauhnik R.
The Impact of Sleep Deprivation on
Physical Activity.
Proceedings of Socratic Lectures.
2024, 10, 35-40.
<https://doi.org/10.55295/PSL.2024.16>

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Abstract:

Proper amount of sleep has a critical role in biological processes and overall health and is linked to negative health outcomes, such as diabetes, heart disease, brain stroke, weight changes, pain, mood swings, Alzheimer's disease, cognitive health, chromosome changes etc. Despite dedicating one-third of our lives to sleep, a substantial portion of the world's population faces sleep deprivation. Insufficient sleep goes beyond simple tiredness, and it is affecting humans metabolic, cardiovascular, cognitive, and emotional dimensions. When it comes to physical activity and athletic performance, sleep deprivation manifests in compromised reaction time, accuracy, vigour, submaximal strength, and endurance. These challenges also affect athlete's cognitive functions such as judgment and decision-making. In the context of athletic performance, even partial sleep deprivation can lead to significant impairments. Relationship between sleep and physical activity was found as emphasizing the importance of adequate sleep for optimal performance and shows that good sleep hygiene and recommended amount of physical activity really go hand in hand contributing to overall well-being including physiological and mental health.

Keywords: Sleep deprivation; Physical activity; Athletic performance, Metabolic health; Cognitive functions, Global prevalence.



1. Sleep hygiene and sleep deprivation

1.1. What is sleep and why we need it

Sleep is defined as natural and reversible state marked by reduced responsiveness to external stimuli and relative inactivity, accompanying a loss of consciousness (Rasch & Born, 2012). Sleeping represents the supreme support for human health, constituting a fundamental biological imperative. An average human dedicates approximately one-third of their lifespan to this crucial physiological function (Hirshkowitz et al., 2015). Furthermore, sleep serves as a key opportunity for the body's reparative processes (Bandyopadhyay & Sigua, 2019). It does not represent just a state where our responses are reduced, but it has 4 stages and they all have their own important role (Rasch & Born, 2012). Stages of sleep are presented in **Figure 1**.

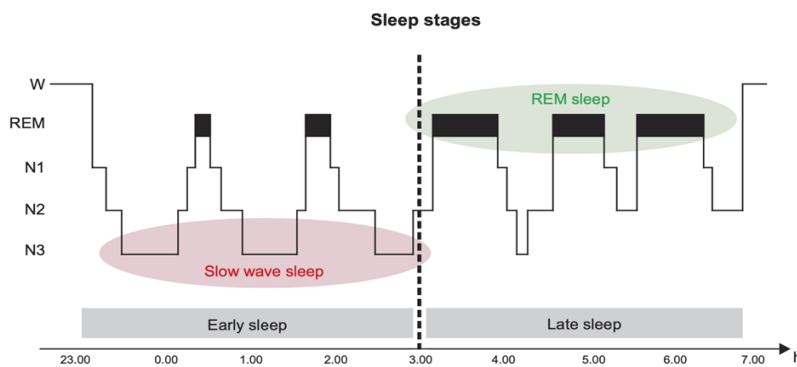


Figure 1. Stages of sleep; N1 = a stage of falling asleep/light sleep, N2 = stage of slower heart rate and decrease of body temperature, N3 = slow-wave sleep; stage of deep sleep and body repairation prosesses, REM sleep (stands for rapid-eye movement sleep) = phase of dreaming and skeletal muscle atonia (Racsch & Born, 2012).

It is visible in Figure 1 that slow wave sleep (N3) predominates in the early hours of sleep and REM sleep becomes more dominant in the later hours of sleep (Rasch, Born, 2012). But sleep is not just a collection of physiologic processes that occur together at the intersection of rest and activity. It is a non-negotiable biological state that is necessary for the maintenance of human life. Ensuring a plentiful duration of quality sleep, has numerous advantages on our health and it is the key to a good quality of life, such as elevated immunity, mental health and emotional resilience, cognitive advancements, physical fitness and energy balance, cardiovascular benefits, and metabolic regulation (Hirshkowitz et al., 2015). As such, it is important to consider developmental changes in sleep, which reflect directly on brain development. In preschool-aged children, decreases in napping have been associated with higher vocabulary and enhanced memory. Recent studies also report associations between sleep micro-structure and brain maturation in youths (Mason et al., 2021).

1.2. Sleep deprivation and recommended duration of sleep

Obviously sleep deprivation occurs when a person is not able to get enough sleep. The amount of sleep needed to feel refreshed, and function well depends on the individual and varies across the ages. Many people refer to 5 or 6 hours as good enough amount of sleep, but that is not enough time for our body to regenerate properly. As said earlier sleep is a very important part of our development, so it is expected that babies and very young kids need more time to dedicate to this important part of our 24h cycle (Mason et al., 2021). Recommended amount of sleep for every age group is visible in **Figure 2**.

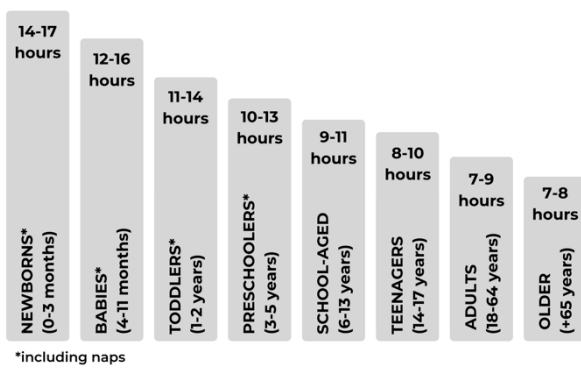


Figure 2. Recommended duration of sleep (Hirshkowitz et al., 2015).

2. Prevalence of sleep deprivation and its effects on human body

Sleep deprivation became a great problem, affecting a substantial portion of the world population. According to research conducted by the American Thoracic Society (Bandyopadhyay & Sigua, 2019), one-third of the US adult population fails to achieve the recommended seven hours of sleep. This prevalent problem is also noticeable across other age groups, with an approximately 50-70 million adults in the United States suffering from sleep disorders (Baranwal, 2023). The impact of insufficient sleep also represents a great problem with students, especially those in high schools and universities. A study conducted by Albqoor and Shaheen (2021) on university students in Jordan has shown poor sleep quality among the student population. Interestingly, the study found that students with lower income, those who were smokers, physically inactive and used media devices before bed, experienced the highest increase in sleep deprivation. The prevalence of sleep deprivation is alarming among high school students, with 73% receiving less than 8 hours of sleep and 58% of middle school students getting less than 9 hours of sleep per night.

Obviously not getting enough sleep is the most common cause of sleep deprivation, but other causes also include poor sleeping habits, circadian rhythm disturbance (e.g. delayed sleep phase), sleep disorders like insomnia, restless leg syndrome and sleep apnoea, use of medications or drugs, jet lag when traveling across multiple time zones, late shift work etc. (Hirshkowitz et al., 2015). Reducing your sleep time by even 1 hour can impact your thought process and reaction time the following day, which was found to be in correlation with car crashes and other accidents. Lack of sleep can also lead to chronic fatigue, potentially affecting work or school performance (Lo et al., 2016). The main impact of sleep deprivation extends well beyond the fact that we can be tired after not getting enough sleep, but it lives consequences on various dimensions of health. Inadequate sleep disrupts fundamental physiological processes, such as metabolic or cardiovascular health. Insufficient nocturnal sleep leads to impaired glucose processing, which is elevating the risk for developing type 2 diabetes. Cardiovascular health can be negatively effected by consequences such as elevated blood pressure, increased inflammation, and physiological stress responses, contributing to a 48% increased likelihood of heart disease and a 15% increased risk of stroke in adults that sleep regularly less than 6 hours per night (Liew & Aung, 2021).

The role of sleep in vascular restoration becomes evident, with deficiencies potentially leading to vessel damage and severe conditions such as aneurysms, atherosclerosis, and ischemia (Liew & Aung, 2021). Cognitive functions can also be effected by sleep deprivation, since sleep-deprived brain need significantly more effort to complete any tasks, which can lead to bad decisions or work mistakes. Beyond the physical outcomes, sleep deprivation can also impact mood, energy levels and irritability, which is reflecting the intricate our mental health and well-being (Killgore, 2010). Another result of sleep deprivation



vation can be disrupted hormonal regulation, which is influencing child's growth and affecting appetite and glucose breakdown in adults (Davies et al., 2014). On a molecular level, sleep deprivation affects chromosome telomeres, contributing to genetic instability and potentially reducing cell lifespan. Disruptions extend to brain circuits, molecules, and genes governing the sleep-wake cycle, affecting both cognition and emotional responses (Murillo-Rodriguez et al., 2012). Poor sleep has an influence on executive function and declarative memory (Lo et al., 2016) and is prospectively linked with the development and progression of Alzheimer's disease (Grandner & Fernandez, 2021). Chronic sleep loss provides oxidative stress, which can potentially increase DNA damage and slow down repair processes that can also negatively produce various disorders, including reproductive and nephrological issues (Liew & Aung, 2021).

Since sleep deprivation has also been associated with several medical conditions, we can easily say prioritizing quality sleep should be seen as a fundamental strategy for optimal physical and mental health.

3. Impact of sleep deprivation on physical activity and athletic performance

In exploring the relationship between sleep and physical activity, researchers have found compelling evidence of sleep deprivation influencing various of performance components. Sleep deprivation not only impairs reaction time, accuracy, vigour, submaximal strength, and endurance but also compromises cognitive functions such as judgment and decision-making (Vitale et al., 2019). The consequences extend to resistance training outcomes and metabolic health, with just three consecutive nights of sleep restriction proving sufficient negative impacts (Knowles et al., 2018). The significance of the postural control system in sports and physical activity cannot be overlooked. Sleep deprivation has higher impact on men, which we can explain with higher Centre of Pressure (COP) values in postural control testing, underscores the gender-specific sensitivity to sleep disruption. This heightened sensitivity translates into reduced postural stability, posing an increased risk of injury during physical activity in both genders (Olpinska Lischka et al., 2021). Research by Wilms et al. (2020) indicates that the impact of sleep loss on physical activity is more pronounced when sleep is restricted during the second half of the night compared to the first half. Taking a closer look at athletes, even partial sleep deprivation, amounting to just 4 hours of sleep, can result in subtle yet potentially significant impairments in athletic performance (Cullen et al., 2019). The heightened risk of injury in athletes due to decreased attention and impaired judgment is further highlighted, with evidence suggesting that obtaining less than 8 hours of sleep per night is associated with an increased risk of injury (Tsukahara et al., 2023).

One such novel concept is "banking sleep," a practice involving sleep extension before a planned night of intentional sleep deprivation before a sporting event. This approach, as proposed by Vitale et al. (2019), suggests that intentionally extending sleep in anticipation of sleep deprivation may serve as a proactive strategy to enhance performance. The concept of "banking sleep" challenges conventional perspectives on the immediate consequences of sleep loss and underscores the potential benefits of prioritizing sleep in the days leading up to a crucial athletic event. Considering these findings, it becomes evident that the relationship between sleep and athletic performance is subtle, not only for the consequences of sleep deprivation but also for potential advantages of strategic sleep extension.

4. Conclusion

We can conclude that sleep and physical activity go hand in hand when it comes to influence of sleep deprivation on physical activity and the impact of physical activity on sleep patterns. Despite their positive interaction, maintaining even a relatively low volume of physical activity can decrease the risks for insufficient sleep duration. Engaging in physical activity in the morning has been especially beneficial to optimize sleep hygiene, as suggested by Valente et al. (2023). The results in research of Kizilkilic et al.



(2023) are showing the importance of physical activity as a powerful intervention for an overall well-being. Moreover, the importance of sleep as a crucial daily regulator of both physical and mental health throughout all life stages is highlighted. Sleep disorders are linked to significant morbidity and are associated with various medical and psychiatric conditions. It is established that sleep deprivation, especially when sleep duration is lower than 7 hours per night, can result in adverse health outcomes. Recognizing sleep as a vital physiological function, it is crucial to acknowledge its paramount role in facilitating effective exercise recovery. In conclusion, both adequate sleep and regular physical activity are integral components of a holistic approach to maintain optimal health and well-being.

Conflicts of Interest: The authors declare no conflict of interest.

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