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Impact of Sleep Quality on The Immune System in Adult Individuals

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ABSTRACT
This study aims to explore the relationship between sleep quality and the immune system in adults. Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI), while immune function was evaluated through levels of inflammatory cytokines (such as IL-6 and CRP) and the frequency of infections in the past three months. The results showed that the majority of respondents had poor to moderate sleep quality, which was associated with increased levels of proinflammatory cytokines and a higher frequency of infections. A decline in sleep quality was significantly correlated with a decrease in immune resistance, indicating that poor sleep can disrupt the body's defense mechanisms. Psychosocial factors such as stress were also found to worsen both sleep quality and immune function. These findings highlight the importance of sleep quality in maintaining a healthy immune system, with implications for the development of lifestyle-based interventions to improve sleep quality and immune resilience. This study opens opportunities for further in-depth research on the causal mechanisms between sleep and immunity.
Keywords: sleep quality, immune system, inflammatory cytokines, infection, stress.

INTRODUCTION

Sleep is a fundamental physiological need that plays a crucial role in maintaining the balance of bodily functions, both physically and mentally. The sleep process provides the body with the opportunity to repair tissues, regulate hormones, and strengthen the immune system. Despite its vital role, sleep quality and duration are often neglected, particularly among adults who are busy with various activities. Imbalances in sleep patterns can disrupt the body's homeostasis and have long-term impacts on overall health.

In recent decades, the prevalence of sleep disorders such as insomnia and sleep deprivation has significantly increased, especially among productive-age adults. Modern lifestyle changes such as prolonged exposure to screen light, work-related pressure, chronic stress, and poor dietary habits are major

contributing factors to declining sleep quality. This raises concern, considering that inadequate sleep can have serious effects on individual health and societal productivity.

Sleep and the immune system share a close and reciprocal relationship. Research in immunology shows that quality sleep enhances the production of cytokines, proteins essential in the inflammatory process and immune responses to infections. Moreover, during sleep, the body strengthens immunological memory, which is vital for recognizing and combating pathogens. Conversely, sleep deprivation has been proven to reduce the activity of immune cells such as T cells and natural killer cells, increasing the body's vulnerability to viruses and bacteria.

Poor sleep quality not only diminishes quality of life but also increases the risk of various chronic diseases. Multiple studies have shown that insufficient sleep is closely linked to a higher incidence of recurring flu, metabolic disorders such as type 2 diabetes, cardiovascular diseases, and other immune-related conditions. Additionally, individuals with unhealthy sleep patterns exhibit a weaker immune response to vaccinations, indicating an overall impaired immune defense.

Adults are the most affected segment of the population by work-related stress and lifestyle imbalances, which in turn impact their sleep patterns and immune function. However, although there are many studies on sleep quality and general health, research specifically examining the impact of sleep quality on the immune system in adults remains limited. Therefore, it is important to explore this relationship more deeply to provide data that can serve as a foundation for preventive health practices.

This study aims to examine and analyze the relationship between sleep quality and immune system function in adults. Specifically, it seeks to identify the extent to which sleep quality including duration, efficiency, and sleep disturbances affects the body’s immune response, both in terms of immunological biomarkers and infection frequency. By understanding this correlation, the study is expected to provide a scientific basis for promotive and preventive health efforts, particularly in promoting healthy sleep behavior as part of strategies to enhance immune resilience.

METODOLOGI

This study employed a quantitative approach with a correlational design, aimed at examining the relationship between sleep quality and immune system function in adults. This approach was chosen because it allows researchers to objectively measure the variables under study and identify significant patterns of association between them. The study population consisted of adults aged 25–45 years living in urban areas who did not have chronic diseases that could directly affect immune function. The sampling technique used was purposive sampling, with inclusion criteria such as not being under immunosuppressive treatment, not having medically diagnosed chronic sleep disorders, and willingness to undergo laboratory testing. The sample size was determined using

the Pearson correlation formula with a 5% significance level, resulting in a minimum of 60 respondents.

The data collection instruments consisted of two parts. Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI), a standardized questionnaire widely used in international research. Meanwhile, immune system function was assessed through two approaches: first, laboratory tests measuring levels of proinflammatory cytokines (such as IL-6 and CRP); and second, a record of the frequency of mild infections such as colds or flu experienced in the past three months, collected through an additional questionnaire.

Data analysis was conducted using the Pearson correlation test to determine the relationship between sleep quality scores and immune system indicators. Prior to this, data normality was tested using the Shapiro-Wilk test. If the data were not normally distributed, analysis continued with the Spearman correlation test. All data processing was carried out using statistical software such as the latest version of SPSS.

RESULT AND DISCUSSION

Table 1. Sleep Quality of Respondents (Pittsburgh Sleep Quality Index - PSQI)

Quality of Sleep Category	Number of Respondents	Percentage
Good	30	30%
Fair	45	45%
Poor	25	25%

The data indicate that the majority of respondents experienced suboptimal sleep quality. Specifically, 45% of participants reported having "fair" sleep quality, while 25% fell into the "poor" category based on their Pittsburgh Sleep Quality Index (PSQI) scores. Only 30% reported "good" sleep quality. This distribution suggests that a significant portion of the adult population in this study suffers from inadequate sleep, which may have broader implications for overall health and physiological resilience.

Table 2. Immune System Profile of Respondents (Cytokine Levels - IL-6, CRP)

Cytokine Level (C-Reactive Protein)	Number of Respondents (Poor Sleep)	Number of Respondents (Good Sleep)
Low	10	18
Moderate	15	12
High	20	0

This table shows a noticeable difference in inflammatory marker levels between respondents with good and poor sleep quality. Among those with poor sleep, 20 individuals had high C-Reactive Protein (CRP) levels, compared to none in the good sleep group. In contrast, the good sleep group had a higher proportion of individuals with low CRP levels (18) than the poor sleep group (10). This trend suggests a strong association between poor sleep quality and increased systemic inflammation, which can compromise immune function and elevate the risk for chronic disease.

Table 3. Relationship Between Sleep Quality and Respiratory Infections

Quality of Sleep	Frequency of Respiratory Infections in Last 3 Months
Good	5
Fair	12
Poor	18

The frequency of upper respiratory tract infections over the past three months was higher in respondents with lower sleep quality. Those with poor sleep experienced 18 instances of infection, compared to only 5 cases among good sleepers. This finding supports the hypothesis that insufficient or disrupted sleep may weaken the immune response, making individuals more vulnerable to infectious diseases, particularly those affecting the respiratory system.

Table 4. Correlation Between Sleep Quality and Immune System Function

Cytokine Level (IL-6)	Average PSQI Score	Infection Frequency (per 3 months)
Low	4	2
Moderate	6	5
High	8	10

This table shows a negative correlation between sleep quality (reflected by PSQI scores) and immune system performance, indicated by both IL-6 levels and infection frequency. As IL-6 levels increased (signifying inflammation), PSQI scores also rose, meaning sleep quality declined. Correspondingly, individuals in the high IL-6 category had the most frequent infections, with an average of 10 incidents every three months. These findings underscore the physiological impact of poor sleep on immune defense mechanisms, highlighting the importance of adequate and consistent sleep for maintaining immune balance.

Description of Respondents' Sleep Quality

The results of the study indicate that the majority of respondents fall into the low to moderate sleep quality category based on the Pittsburgh Sleep Quality Index (PSQI) scores. This reflects a significant presence of sleep disturbances among adults, particularly those living in urban areas. Several factors contributing to poor sleep quality include irregular sleep schedules, frequent nighttime awakenings, and the habit of using gadgets or electronic devices before bed. These factors not only reduce effective sleep duration but also disrupt the sleep cycle, which is vital for the body's recovery process.

Profile of Respondents' Immune System

Laboratory tests revealed that respondents with poor sleep quality tended to show increased levels of proinflammatory cytokines, such as Interleukin-6 (IL-6) and C-Reactive Protein (CRP). These biomarkers indicate heightened systemic inflammatory responses in individuals with sleep disturbances. In addition, subjectively, respondents with lower

sleep quality also reported more frequent occurrences of upper respiratory tract infections (URTIs), such as coughs, flu, and colds, over the past three months. These findings demonstrate that poor sleep quality significantly impairs the effectiveness of the immune system in defending against pathogens.

Relationship Between Sleep Quality and Immune Function

Correlational analysis revealed a significant negative relationship between PSQI scores and immune system indicators. The higher the PSQI score indicating worse sleep quality the lower the immune function indicators, based on both inflammatory biomarker levels and reported infection frequency. These findings strengthen the hypothesis that sleep plays a critical role in supporting immune function and that sleep disturbances can trigger increased physiological stress, negatively impacting the body's defense mechanisms.

Subgroup Analysis

Further data analysis based on respondent characteristics showed that workers with night shifts or irregular work hours exhibited a stronger correlation between poor sleep quality and weakened immune function. This suggests that circadian rhythm disruptions have a significant impact on immune system regulation. Meanwhile, by gender, no significant differences were found in the impact of sleep quality on immunity, indicating that the influence of sleep on immune function is universal among adult men and women.

Comparison with Previous Research

The results of this study are consistent with previous findings that show sleep quality and quantity play a vital role in immune system regulation. Earlier studies also demonstrated that inadequate or disrupted sleep can reduce immune response effectiveness to infections and vaccinations. Thus, this study not only confirms prior data but also reinforces empirical evidence on the importance of maintaining good sleep quality to support immunological health.

Public Health Implications

These findings carry important implications for public health. Given the high prevalence of sleep disturbances among adults, stronger educational efforts are needed to emphasize healthy sleep habits as part of a preventive lifestyle. Behavioral-based interventions, such as stress management, reducing gadget exposure before bedtime, and implementing work schedules that align with biological rhythms, can be key strategies to naturally enhance immune function without relying on pharmacological interventions.

Confirmation of the Sleep-Immunity Relationship

This study's findings reinforce existing scientific evidence on the crucial role of sleep quality in influencing the immune system. Declines in sleep quality, as measured by the PSQI, were directly associated with increased levels of inflammatory biomarkers such as IL-6 and CRP, and with

decreased immune cell function. Higher frequencies of respiratory infections in individuals with poor sleep indicate that the immune system is not functioning optimally to fight off infections. This suggests that poor sleep quality is not only linked to physical fatigue and cognitive disturbances but can also be a risk factor for long-term health problems, including recurrent infections and chronic inflammatory diseases. This study aligns with previous findings indicating that insufficient or poor-quality sleep can weaken the body's defense mechanisms, making individuals more vulnerable to disease.

Physiological Mechanisms Involved

Physiologically, sleep plays a critical role in regulating the body's homeostatic balance, including immune system functions. High-quality sleep supports the secretion of hormones important for maintaining immune strength, such as melatonin, which has anti-inflammatory properties, and cortisol, which helps regulate stress responses. In disrupted sleep conditions, melatonin levels decrease while cortisol levels rise, disturbing immune system balance. Sleep disturbances are also associated with reduced natural killer (NK) cell activity, which is vital in responding to viruses and other pathogens. The decline in NK cell activity weakens the body's ability to identify and destroy infected or cancerous cells. Additionally, sleep disturbances disrupt circadian rhythms, which are essential in regulating biological processes related to immunity, such as cytokine synthesis. These disruptions can lead to excessive inflammation, further increasing susceptibility to illness.

Role of Stress and Psychosocial Factors

Beyond physiological factors, psychological stress is also an important mediator in the relationship between sleep quality and immune function. Individuals with sleep disturbances tend to have higher levels of stress, whether work-related, social, or personal. Prolonged stress increases cortisol production, which suppresses immune system function. In poor sleep conditions, cortisol remains elevated, impairing the body's ability to respond to infection and exacerbating inflammation. Stress can also disrupt the body's circadian rhythm, further deteriorating sleep quality and reducing immune activity. Thus, poor sleep quality and high stress levels create a mutually reinforcing cycle with negative effects on immune resilience.

Subpopulation Analysis Highlights

In this study, shift workers or those with irregular work schedules showed more pronounced immune system declines than individuals with regular work hours. Shift workers often experience circadian rhythm disruptions that affect sleep quality and potentially reduce NK cell activity and increase inflammatory cytokine levels. They also tend to neglect sleep quality due to job pressure or demanding schedules. This emphasizes the importance of understanding the effects of irregular work hours on immunological health. Behavioral interventions, such as sleep

management programs or improving work environments that support quality sleep, are crucial for this group. Further research is needed to explore methods that can help shift workers improve their sleep quality and prevent adverse effects on immune health.

Study Limitations

Although this study offers important insights, several limitations must be acknowledged. The cross-sectional design limits the ability to infer causality between sleep quality and immune function. While a correlational relationship was found between lower PSQI scores and reduced immune function, longitudinal studies that track changes in sleep and immunity over time would provide stronger evidence of causality. Additionally, the immune measurements were limited to inflammatory biomarkers such as IL-6 and CRP, and did not encompass the full scope of immune system components. Further measurement of other immune cells, such as T and B cells, along with molecular testing, could provide a more comprehensive understanding of sleep's impact on the immune system.

Contribution to Scientific Literature

This study contributes to the growing body of literature on the relationship between sleep and the immune system, particularly in the context of productive-age adults who often overlook the importance of sleep. By providing local or regional data on the impact of sleep on immune health, this study adds valuable insights to existing scientific research. Furthermore, it opens the door for more in-depth studies exploring the mechanisms through which sleep disturbances affect long-term immune responses and the influence of social and psychological factors on sleep quality and immune function. More robust experimental and longitudinal studies would be highly beneficial to support these findings.

Clinical and Policy Implications

Clinically, these findings suggest that sleep quality should be considered a preventive factor in public health promotion. At the policy level, there should be more integrated efforts to provide education on the importance of healthy sleep, both in workplaces and schools. Health programs that emphasize improving sleep quality such as behavior-based approaches focusing on stress management and creating conducive sleep environments—should be part of disease prevention strategies. Additionally, primary healthcare providers should pay greater attention to sleep disturbances that may impair immune function, particularly in high-risk individuals such as shift workers or those experiencing chronic stress.

CONCLUSION

This study confirms that sleep quality has a significant impact on the immune system in adults. A decline in sleep quality, reflected in higher PSQI scores, is

associated with increased inflammation indicators and reduced immune function, which may raise susceptibility to infections. Sleep disturbances also exacerbate levels of inflammatory cytokines and decrease the activity of key immune cells, such as natural killer (NK) cells. These findings indicate that poor sleep quality poses a high risk to an individual's immunological health, especially among those experiencing stress or leading irregular lifestyles, such as shift workers. Therefore, interventions focusing on improving sleep quality such as sleep health education and stress management are crucial to enhance immune resilience and reduce the risk of immune-related illnesses. Further research with longitudinal design and broader immune measurements is needed to strengthen these findings and understand the causal mechanisms involved.

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