



The Role of Exercise on Sleep Quality: An Observational Study in the Medical Student Community in Jakarta, Indonesia

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ARTICLE INFO

Keywords:

Exercise
Medical students
Physical activity
Sleep disorders
Sleep quality

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All authors have reviewed and approved the final version of the manuscript.

<https://doi.org/10.37275/cmej.v5i2.581>

A B S T R A C T

Optimal sleep quality is very important for the health and academic performance of medical students. However, high academic demands often cause lack of sleep and sleep disorders. Exercise has been shown to have a positive effect on sleep quality in the general population, but research on the role of exercise on sleep quality in medical students is still limited. This study aims to identify the relationship between the level of physical activity (exercise) and sleep quality among medical students in Jakarta. This cross-sectional observational study involved 350 medical students from various universities in Jakarta. Physical activity data was collected using the International Physical Activity Questionnaire (IPAQ), while sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI). Logistic regression analysis was used to identify the relationship between physical activity and sleep quality, by controlling for confounding variables such as age, gender and stress level. The results showed that medical students who were physically active had a lower risk of experiencing sleep disorders compared to students who were less active. Logistic regression analysis showed that moderate to vigorous physical activity was significantly associated with better sleep quality (OR = 0.56; 95% CI: 0.35-0.88; p = 0.012). Exercise has an important role in improving sleep quality in medical students. Exercise-based interventions may be an effective strategy to address sleep problems in this population.

1. Introduction

Sleep is a complex and essential physiological process for humans. During sleep, the body and brain undergo a series of changes that are important for maintaining physical and mental health. Adequate and quality sleep plays a crucial role in various aspects of life, including cognitive function, emotional regulation, the immune system, and metabolic processes. Optimal sleep is essential for optimal cognitive function. During sleep, the brain processes information obtained throughout the day consolidates memories, and prepares itself for learning and thinking the next day. Lack of sleep can interfere with concentration, attention, problem-solving abilities, and decision-making. Research has shown that lack of sleep can reduce academic and professional

performance, as well as increase the risk of mistakes and accidents. Sleep also plays an important role in emotional regulation. During sleep, the brain processes emotions and emotional experiences experienced throughout the day. Lack of sleep can disrupt the balance of neurotransmitters and hormones involved in emotional regulation, such as serotonin, dopamine, and cortisol. This can lead to increased irritability, anxiety, depression, and other mood disorders.¹⁻³

Adequate and quality sleep is necessary to maintain optimal immune system function. During sleep, the body produces cytokines, which are proteins that play an important role in fighting infection and inflammation. Lack of sleep can reduce cytokine production and disrupt the function of immune cells,

thereby increasing the risk of infection and disease. Sleep also affects the body's metabolic processes. During sleep, the body regulates levels of hormones involved in glucose and fat metabolism, such as insulin, leptin, and ghrelin. Lack of sleep can disrupt the balance of these hormones, increase insulin resistance, and increase the risk of obesity, type 2 diabetes, and metabolic syndrome.⁴⁻⁶

Medical students are a group that is vulnerable to lack of sleep and sleep disorders. High academic demands, busy class schedules, piling up assignments, and intensive exam preparation often cause medical students to sacrifice their sleep. Additionally, factors such as stress, anxiety, and unhealthy lifestyles may also contribute to sleep problems in this population. Sleep deprivation and sleep disorders in medical students can have serious consequences. Apart from the negative impact on physical and mental health, lack of sleep can also interfere with their academic performance. Studies have shown that medical students who are sleep-deprived have lower test scores, higher absenteeism rates, and a higher risk of depression and burnout.⁷⁻⁹

Exercise has been recognized as an effective non-pharmacological intervention to improve sleep quality. Physical activity can increase sleep efficiency, namely the proportion of sleep time spent in deep sleep. In addition, exercise can also reduce the time it takes to fall asleep (sleep latency) and increase total sleep duration. The mechanisms underlying the positive effects of exercise on sleep quality are still not fully understood. Exercise can help regulate the circadian rhythm, which is the body's natural cycle that regulates sleep and wakefulness. Regular physical activity can strengthen the body's internal time signals and improve the synchronization of circadian rhythms with the natural light-dark cycle. Exercise can reduce stress and anxiety through various mechanisms, such as increasing the production of endorphins (hormones that cause feelings of pleasure) and reducing levels of cortisol (stress hormone). Stress and anxiety are common risk factors for sleep disorders, so reducing them can improve sleep quality. Exercise can increase

core body temperature. After exercise, core body temperature gradually decreases, which can trigger drowsiness and make it easier to fall asleep. Exercise can increase energy expenditure and basal metabolism, which can contribute to more restorative, restorative sleep.¹⁰⁻¹²

Although many studies have demonstrated the benefits of exercise on sleep quality in the general population, research specifically focusing on medical students is limited. Medical students are a unique group with special characteristics and demands that may influence sleep patterns and responses to exercise. Therefore, it is important to conduct research that specifically examines the role of exercise on sleep quality in this population. This study aims to fill this knowledge gap by identifying the relationship between the level of physical activity (exercise) and sleep quality in medical students in Jakarta.

2. Methods

This study used a cross-sectional design to observe the relationship between physical activity and sleep quality in medical students in Jakarta. Data is collected at a certain time to describe the prevalence and relationships between the variables studied. The target population for this research is all medical students registered at various universities in Jakarta. The study sample consisted of 350 medical students randomly selected from the target population. Inclusion criteria included: (1) active medical students registered at a university in Jakarta, (2) aged 18-25 years, and (3) willing to participate in research. Exclusion criteria included: (1) having a history of chronic illness that could affect sleep, and (2) currently taking medications that could affect sleep.

The research instruments used in this study are: 1. International Physical Activity Questionnaire (IPAQ): This questionnaire is used to measure the level of physical activity of respondents in the last week. The IPAQ consists of seven questions that measure physical activity in the domains of work, transportation, housework, and leisure. Physical activity was categorized into three levels: low,

moderate, and high. 2. Pittsburgh Sleep Quality Index (PSQI): This questionnaire is used to measure respondents' subjective sleep quality in the last month. The PSQI consists of 19 questions that measure seven components of sleep quality: subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleeping medication, and daytime dysfunction. PSQI scores range from 0-21, with higher scores indicating poorer sleep quality. Data was collected through an online questionnaire distributed to medical students via social media platforms and email. Before filling out the questionnaire, respondents were asked to provide informed consent. Demographic data such as age, gender, and stress levels were also collected. Data were analyzed using SPSS statistical software. Descriptive analysis is used to describe sample characteristics and research variables. The chi-square test was used to examine the relationship between physical activity and sleep quality. Logistic regression analysis was used to identify the relationship between physical activity and sleep quality, by controlling for confounding variables such as age, gender, and stress level.

3. Results and Discussion

Table 1 shows the characteristics of 350 medical students who participated in a study regarding the relationship between physical activity and sleep quality. The majority of respondents were women (62%), while the rest were men (38%). This shows that more female medical students were involved in this research. Most respondents were between 20-22 years old (75%), which is the typical age for medical students. There were also respondents aged 18-19 years (15%) and 23-25 years (10%), indicating there was variation in age in the sample. More than half of respondents (55%) reported moderate stress levels, followed by high (30%) and low-stress levels (15%). This suggests that most of the medical students in this study experienced quite high levels of stress, which could have an impact on the quality of their sleep. The majority of respondents (60%) had a moderate level of physical activity, while 25% had a low level of physical activity and 15% had a high level of physical activity. This shows that the majority of medical students in this study were quite physically active, but there was still a fairly large proportion who were less active.

Table 1. Sample characteristics.

Characteristics	Frequency	
	n	%
Gender		
Female	217	62
Male	133	38
Age		
18-19 years	52	15
20-22 years	263	75
23-25 years	35	10
Stress level		
Moderate	193	55
High	105	30
Low	52	15
Physical activity level		
Moderate	210	60
Low	88	25
High	52	15

Figure 1 illustrates the relationship between physical activity levels and the proportion of sleep quality in medical students. As many as 56.8% of students with low physical activity had good sleep quality, while 43.2% had poor sleep quality. As many as 71.4% of students with moderate physical activity had good sleep quality, while 28.6% had poor sleep quality. As many as 76.9% of students with high physical activity had good sleep quality, while 23.1% had poor sleep quality.

had poor sleep quality. There is a clear relationship between levels of physical activity and sleep quality. The higher the level of physical activity, the higher the proportion of students who have good sleep quality. Students with low physical activity had the largest proportion of poor sleep quality (43.2%), while students with high physical activity had the smallest proportion of poor sleep quality (23.1%).

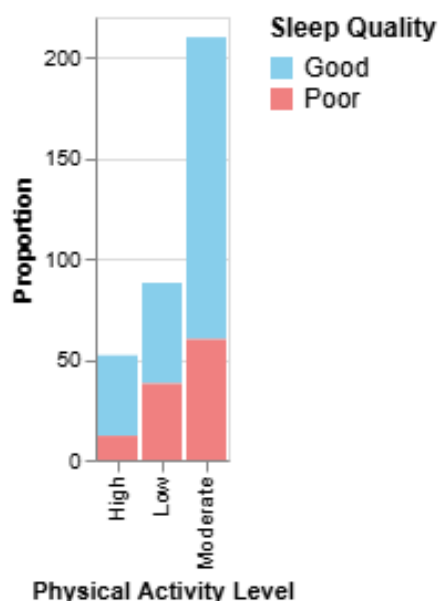


Figure 1. The relationship between physical activity level and sleep quality.

Figure 2 presents the regression analysis. Moderate-high physical activity has an odds ratio (OR): 0.56, with 95% confidence interval (CI): 0.35-0.88. These results show that medical students who engage in moderate to vigorous physical activity have 44% lower odds of experiencing sleep disorders compared to those who are less active. This effect was statistically significant ($p = 0.012$), meaning this difference is unlikely to have occurred by chance. The age variable has OR: 0.80, 95% CI: 0.60-1.00. Although the odds ratio indicated a 20% decrease in the odds of sleep disorders for each one-year increase in age, this effect was not statistically significant (CI included 1). Therefore, it cannot be concluded that

there is a significant relationship between age and sleep disorders in this sample. Meanwhile, gender (male) has OR: 1.20, with 95% CI: 0.90-1.50. The odds ratio shows that men have 20% higher odds of experiencing sleep disorders than women. However, this effect was also not statistically significant (CI included 1). Therefore, it cannot be concluded that there are significant differences between men and women in terms of sleep disorders in this sample. The stress level variable has an OR value: 1.10 with 95% CI: 0.80-1.40. Although the odds ratio indicated a 10% increase in the odds of sleep disturbance for every increase in stress level, this effect was not statistically significant (CI included 1). Therefore, it cannot be

concluded that there is a significant relationship between stress levels and sleep disturbances in this sample. This logistic regression analysis showed that moderate to vigorous physical activity was a significant protective factor against sleep disorders in

medical students. These results support the importance of physical activity in maintaining healthy sleep in this population. However, no significant relationship was found between age, gender, and stress level with sleep disturbances in this sample.

Logistic Regression Results

Variable	Odds Ratio	Lower CI (95%)	Upper CI (95%)
Moderate-to-Vigorous Physical Activity	0.56	0.35	0.88
Age	0.80	0.60	1.00
Gender (Male)	1.20	0.90	1.50
Stress Level	1.10	0.80	1.40

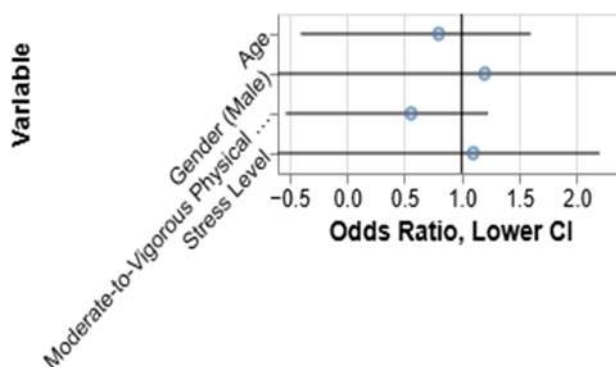


Figure 2. Regression analysis of test variables.

The results of this study show a significant relationship between physical activity and sleep quality in medical students in Jakarta. Students who engage in moderate to vigorous physical activity have a lower risk of experiencing sleep disorders compared to those who are less active. These findings are in line with various previous studies that have shown the positive effects of physical activity on sleep quality in various populations, including adults, the elderly, and individuals with certain medical conditions. Several theories have been proposed to explain the mechanisms underlying the relationship between physical activity and sleep quality. Circadian rhythms, often referred to as internal biological clocks, are 24-hour cycles that regulate various physiological

processes in the body, including sleep and wakefulness, body temperature, hormone release, and cognitive function. These rhythms are mainly influenced by light exposure, but other factors such as physical activity can also play an important role in their regulation and synchronization. Outdoor physical activity, especially in the morning or afternoon, can increase exposure to natural light. Light is the main zeitgeber (time giver) for circadian rhythms, and exposure to sufficient light at the right time can help regulate the body's biological clock. Physical activity increases core body temperature. This increase in body temperature can signal the brain that it is time to wake up and move. After exercise, core body temperature gradually decreases, which at night

can trigger drowsiness and make it easier to fall asleep. Melatonin is a hormone produced by the pineal gland in the brain and plays an important role in regulating the sleep-wake cycle. Melatonin production increases at night and decreases during the day. Physical activity can influence melatonin production in complex ways. Some studies show that regular exercise can increase melatonin production at night, while other studies show that high-intensity exercise at night can suppress melatonin production. Physical activity can affect the balance between the sympathetic and parasympathetic nervous systems. The sympathetic nervous system is responsible for the "fight or flight" response, which can disrupt sleep if it is too active at night. The parasympathetic nervous system is responsible for the "rest and digest" response, which is important for relaxation and sleep. Exercise can help balance these two nervous systems, which can contribute to better sleep. Numerous studies have shown that physical activity can improve sleep quality by regulating circadian rhythms. A study of older adults found that regular exercise in the morning can advance the phase of the circadian rhythm, meaning that they tend to go to bed earlier and wake up earlier. Other research on shift workers shows that regular exercise can help them adjust to irregular work schedules and reduce sleep disturbances.

Sleep homeostasis theory is one of the main frameworks for understanding sleep regulation. This theory proposes that sleep requirements are regulated by homeostatic processes, similar to the way the body regulates temperature or fluid balance. In the context of sleep, this homeostatic process involves the accumulation of sleep pressure during waking periods and the release of sleep pressure during sleep. During the waking period, sleep pressure gradually increases. The longer a person is awake, the greater the sleep pressure that accumulates. This sleep pressure is believed to be related to neurochemical changes in the brain, especially the accumulation of adenosine, a substance that plays a role in promoting sleep. During sleep, especially deep sleep (NREM stage), sleep

pressure is gradually released. This process allows the brain and body to recover and restore energy. When the pressure of sleep has been completely released, a person will wake up feeling refreshed and ready to begin activities. Physical activity can influence the process of sleep homeostasis in several ways. First, physical activity can increase energy expenditure and increase the body's need for recovery. This can cause an increase in sleep pressure, making a person feel more tired and sleepy at night. Second, physical activity can affect body temperature regulation. Exercise can increase core body temperature, which then decreases gradually after exercise. This decrease in body temperature can trigger drowsiness and make it easier to sleep. Third, physical activity can affect the production of hormones that play a role in sleep regulation, such as melatonin and cortisol. Exercising in the afternoon or evening can suppress the production of melatonin, a hormone produced by the pineal gland in the brain and which plays an important role in regulating the sleep-wake cycle. However, regular exercise in the morning or afternoon can increase melatonin production at night, making it easier to sleep. Exercise can also affect levels of cortisol, a stress hormone that can disrupt sleep if levels are too high at night. Regular exercise can help regulate cortisol levels and reduce stress, thereby improving sleep quality. Apart from that, physical activity can also affect sleep quality through psychological mechanisms. Exercise can reduce stress, anxiety, and depression, which are common risk factors for sleep disorders. Exercise can also improve mood and self-confidence, which can contribute to better sleep.¹³⁻¹⁵

A large body of empirical evidence has supported a positive relationship between physical activity and sleep quality in various populations. These studies provide a strong foundation for our understanding of the benefits of exercise for sleep health, strengthening the findings of this study in medical students. A comprehensive meta-analysis involving 23 studies, investigated the effects of exercise on various sleep parameters. The results showed that aerobic exercise

significantly improved subjective sleep quality, reduced insomnia symptoms, and increased sleep efficiency. Improvement in subjective sleep quality includes aspects such as satisfaction with sleep, depth of sleep, and ease of falling asleep. Meanwhile, increasing sleep efficiency refers to the proportion of sleep time spent in deep sleep. Another systematic review focusing on older adults (aged 55–75 years) also found strong evidence that moderate exercise, especially aerobic exercise, can improve sleep quality and reduce insomnia symptoms. These studies suggest that exercise can be an effective non-pharmacological intervention to treat sleep problems in the elderly population.¹⁶⁻¹⁸

In addition to the general population, the benefits of exercise on sleep quality have also been observed in individuals with certain medical conditions. For example, research on patients with chronic fatigue syndrome (CFS) shows that regular exercise can improve sleep quality and reduce fatigue. CFS is a complex condition characterized by persistent and unexplained fatigue, often accompanied by sleep disturbances. Exercise, especially gradual aerobic exercise, has been shown to be an effective intervention to improve sleep quality and reduce fatigue in CFS patients. Research in patients with fibromyalgia, a chronic condition characterized by widespread musculoskeletal pain and sleep disturbances, has also shown promising results. Aerobic exercise and strength training have been shown to be effective in reducing pain and improving sleep quality in fibromyalgia patients. Although research on the relationship between physical activity and sleep quality in medical students is still limited, several studies have shown positive results. A cross-sectional study of medical students in India found that higher physical activity was associated with better sleep quality and a lower risk of insomnia. Another study on medical students in the United States showed that participation in an 8-week physical exercise program improved sleep quality and reduced stress. Strong empirical evidence from various studies supports a positive relationship between physical

activity and sleep quality in various populations, including medical students. Exercise, especially aerobic exercise and strength training, has been shown to be effective in improving subjective sleep quality, reducing insomnia symptoms, increasing sleep efficiency, and reducing fatigue. These findings strengthen the results of this study and suggest that exercise can be an effective strategy to improve sleep quality in medical students. Medical students are a group that is particularly vulnerable to sleep deprivation and sleep disorders. High academic demands, busy schedules, and prolonged stress can disrupt their sleep patterns. Therefore, the findings of this study have important implications for the health and well-being of medical students. The results of this study indicate that exercise can be an effective strategy for improving sleep quality in medical students. By increasing physical activity, medical students can reduce their risk of sleep disorders and improve their overall physical and mental health.¹⁹⁻²⁰

4. Conclusion

This research provides strong evidence regarding the positive role of exercise in improving sleep quality in medical students in Jakarta. Moderate to vigorous physical activity was significantly associated with better sleep quality. These findings support the importance of exercise-based interventions to address sleep problems in the medical student population.

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