# Understanding the Relationship between Sleep Quality and Physical Activity: Implications for Healthy Aging

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## Abstract

**Background:** Understanding the general health and well-being of the aged population requires an understanding of several factors, among which the interplay between physical activity and sleep quality are the most efficient determinants. There is still much to learn about the precise ways that different components of sleep quality affect different kinds of physical activity in older persons, accordingly, the study aims to provide a comprehensive understanding of the interaction between these variables.

**Methods:** An online questionnaire-based investigation was conducted between August and September 2023. This cross-sectional study analyzed data from 1,437 participants aged 50 to 89 years. The questionnaire evaluated levels of physical activity, sleep satisfaction, and demographic data. We used cluster analysis, regression analysis, and factor analysis to investigate the connections between these variables.

**Results:** Factor analysis revealed a single factor that accounted for 51.95% of the variance in all variables linked to sleep, and this factor represented overall quality of sleep. Regression analysis revealed that gender significantly predicted sleep quality, with females reporting lower sleep satisfaction. While strenuous exercise did not significantly affect sleep quality, moderate exercise was a positive predictor of sleep quality that neared statistical significance. Furthermore, cluster analysis revealed that those who engaged in more physical activity had higher-quality sleep.

**Conclusion:** These results highlight the significance of encouraging physical activity to improve older adults' sleep quality. Specific programs that promote moderate exercise may enhance this population's general health and sleep quality. Future research should focus on longitudinal studies to create causality and modify intervention strategies aimed at promoting healthy aging.

**Keywords:** Sleep quality; Physical activity; Elderly population; Health promotion; Healthy aging

## Introduction

The importance of physical activity and sleep for overall health and well-being in aging population has been widely recognized in recent years. Approximately one third of the global population is

estimated to experience insufficient sleep and inadequate physical activity (1). Understanding the determinants of physical activity and sleep quality in the elderly population is crucial for developing effective interventions to promote active lifestyles and improve sleep satisfaction. There is substantial evidence linking poor sleep duration and insufficient physical activity to adverse health outcomes (2,3). Likewise, poor physical activity has also been associated with many health issues. In contrast, engagement in physical activity has been linked to enhanced self-esteem (4), and improved physical and psychological well-being (5-7). The relationship between sleep satisfaction and physical activity has become a focal point of public health research due to its implications for overall well-being and health promotion. However, various sleep-related factors can significantly influence physical activity behaviors, and a comprehensive examination of these relationships is warranted.

Sleep satisfaction encompasses multiple dimensions, including sleep disturbance, sleep efficiency, and sleep replenishment. Poor sleep quality is associated with decreased physical activity and increased sedentary behavior, further exacerbating health risks (8). Sleep disturbance can negatively affect the ability to participate in vigorous and moderate exercise, whereas sleep efficiency and sleep replenishment are essential for recovery and sustained physical activity (9, 10). Understanding how these aspects of sleep satisfaction affect physical activity is critical to developing interventions aimed at improving sleep quality and promoting an active lifestyle.

Previous research has identified several factors that influence physical activity and sleep quality, including age, gender, socioeconomic status, and health conditions. Despite the well-documented relationship between sleep satisfaction and physical activity, significant gaps remain in our understanding of how different dimensions of sleep quality influence various types of physical activity. Most of existing studies have focused primarily on the overall relationship between sleep duration and physical activity, often ignoring the subtle roles of sleep disturbance, sleep efficiency, and

sleep compensation (11, 12). Furthermore, while some research has examined the impact of poor sleep on overall levels of physical activity, few studies have examined how specific sleep issues affect the frequency and intensity of distinct physical activities such as vigorous exercise, moderate exercise, and strength training. (10). Addressing these gaps is critical to develop the targeted interventions that can effectively promote better sleep and increased physical activity, and improving public health outcomes.

To address these gaps, we aimed to provide insights into the intervention of sleep quality and physical activity, with the goal of developing targeted interventions to promote active lifestyles. These findings are expected to demonstrate the importance of sleep satisfaction in influencing physical activity behaviors and provide a comprehensive understanding of the interaction between these variables.

## Materials and Methods

### Participants and Data collection
This cross-sectional study employed online questionnaire and data collection methods through the research institutes Panel Marketing Interactive (PMI) and EMBRAIN over a period of 11 days, from August 27 to September 11, 2023. Data were collected using a self-reported questionnaire that assessed physical activity levels, sleep quality, and demographic information. The study involved a total of 1,437 participants aged between 50 and 89 years. Participants were selected using a stratified sampling method to ensure a representative sample of adults across different age groups. The study was conducted in accordance with ethical standards, and all participants provided informed consent prior to data collection.

### Ethical considerations
This research was performed in accordance with all relevant guidelines and regulations within the Declaration of Helsinki. Informed consent and

ethical approval were waived by the Institutional Review Board of Gachon University.

## Questionnaire

Data were collected using a structured questionnaire designed to capture information on demographic variables, sleep satisfaction, and physical activity levels. The demographic section included questions on gender, age, and marital status. The sleep satisfaction section assessed various dimensions of sleep quality, including sleep disturbance, sleep efficiency, and sleep replenishment. Participants responded to statements such as "It takes a long time for me to fall asleep," "I often wake up during sleep," and "I feel extremely tired in the morning when I wake up" using a four-point Likert scale ranging from "I never felt" to "I always felt".

The physical activity section inquired about the frequency and intensity of different types of physical activities. Questions covered strenuous exercise, moderate exercise, and strength training, with response options ranging from "Not at all" to "Every day."

## Data analysis

The data collected was entered into IBM SPSS ver. 20.0 (IBM Corp., Armonk, NY, USA) for analysis. In our research, we used a combination of factor analysis, regression analysis, and cluster analysis to explore the relationships between sleep satisfaction, physical activity, and demographic variables. A Principal Axis Factoring analysis was employed to identify the underlying dimensions of sleep satisfaction, which revealed a single factor representing overall sleep quality. This factor accounted for 51.95% of the total variance in sleep-related variables, with strong factor loadings indicating that sleep disturbance and sleep efficiency were highly interrelated.

Regression analysis was conducted to examine the impact of demographic variables and physical activity levels on overall sleep quality. The analysis found that gender was a significant predictor of sleep quality, while age and marital status did not significantly influence sleep quality. Although strenuous exercise was not a significant predictor, moderate exercise approached significance, suggesting a potential positive effect on sleep quality. Finally, a K-Means cluster analysis was performed to segment the study population based on their physical activity levels and overall sleep quality. This analysis identified two distinct clusters: one characterized by lower engagement in physical activities and poorer sleep quality, and the other by higher physical activity levels and better sleep quality. These findings highlight the importance of physical activity in promoting better sleep outcomes.

## Results

### General Characteristics

Table 1 presents the descriptive statistics for the demographic variables of the study sample, including gender, age, and marital status. The sample consists of 1,437 participants, with a slightly higher proportion of males (56.1%) compared to females (43.9%). The age distribution of participants is mainly in the age range of 50–69 years, with 48.9% of participants aged 50–59 years and 45% in the age range of 60–69 years, while smaller proportions are in the age range of 80-89 (0.1%), and 70–79 (6.1%), respectively. In terms of marital status, a majority of the participants are married and living with their spouse (84.2%), while smaller percentages are bereavement (3.9%). These demographic characteristics provide a comprehensive overview of the study population, highlighting the predominance of older adults who are married and living with a spouse.

**Table 1:** Descriptive Statistics for Demographic Variables

| Demographic Variable | Frequency | Percent |
|---|---|---|
| *Gender* | | |
| Male | 806 | 56.1 |
| Female | 631 | 43.9 |
| Total | 1431 | 100 |
| *Age* | | |
| 50-59 | | |
| 60-69 | 702 | 48.9 |
| 70-79 | 646 | 45 |
| 80-89 | 87 | 6.1 |
| Total | 2 | 0.1 |
| | 1437 | 100 |
| *Marital Status* | | |
| 1) Married (living with spouse) | 1210 | 84.2 |
| 2) Bereavement | 56 | 3.9 |
| 3) Single | 89 | 6.2 |
| 4) Divorce | 82 | 5.7 |
| Total | 1437 | 100 |

### Factor Structure of Sleep-Related Variables: Identifying the Underlying Dimension of Sleep Quality

A Principal Axis Factoring analysis was conducted on 11 variables related to sleep disturbances and sleep efficacy to identify the underlying dimensions of sleep satisfaction. The Kaiser-Meyer-Olkin measure of sampling adequacy was exceptionally high at 0.948, indicating that the sample was suitable for factor analysis. Bartlett's Test of Sphericity was also significant ($\chi^2(55) = 8814.390$, $p < 0.001$), confirming that the correlations among the variables were sufficient for the analysis.

The factor analysis revealed a single factor that accounted for 51.948% of the total variance across the sleep-related variables. This factor exhibited strong loadings on all variables, with loadings ranging from 0.546 to 0.842, suggesting that the variables are well-represented by this factor. Given the nature of the variables, this factor likely represents a general dimension of "Overall Sleep Quality."

This finding indicates that sleep disturbances and sleep efficacy, as measured in this study, are high-ly interrelated and can be summarized by a single underlying construct. The identification of this factor simplifies the conceptualization of sleep satisfaction and provides a robust measure that can be utilized in subsequent analyses to explore its relationship with other variables, such as physical activity and demographic characteristics.

### Analyzing the Impact of Demographic Variables and Physical Activity on Sleep Quality: Regression Analysis Findings

The regression analysis conducted to explore the impact of physical activities, demographic factors, and their interactions on overall sleep quality yielded notable findings. The complete results are presented in Table 2.

The model achieved an R-squared value of 0.020, indicating that approximately 2% of the variability in overall sleep quality could be explained by the included predictors. Although this percentage is modest, the F-statistic of 4.747 ($p < .000$) signifies that the model was statistically significant, suggesting that the variables collectively have a discernible effect on sleep quality.

**Table 2:** Regression Analysis for Predicting Overall Sleep Quality

| Variables | Coefficients | Standard Error | Beta | t-value | P-value |
|---|---|---|---|---|---|
| Constant | -0.002 | 0.025 | | -0.082 | 0.935 |
| Z-score: Age Record | 0.003 | 0.025 | 0.003 | 0.109 | 0.913 |
| Z-score: Strenuous Exercise | 0.027 | 0.040 | 0.028 | 0.670 | 0.503 |
| Z-score: Moderate Exercise | 0.078 | 0.040 | 0.080 | 1.941 | 0.053 |
| Z-score: Gender | -0.068 | 0.026 | -0.071 | -2.677 | 0.008 |
| Z-score: Marital Status | -0.019 | 0.026 | -0.019 | -0.725 | 0.468 |
| Interaction: Age and Strenuous Exercise | 0.026 | 0.024 | 0.028 | 1.056 | 0.291 |

### Influence of Individual Predictors

**Demographic Factors:** The gender variable emerged as a significant predictor of sleep quality (B = -0.068, p = 0.008), indicating that gender differences are crucial in understanding variations in sleep quality. The negative coefficient suggests that the gender coded as '1' (potentially females if coded 0 for males and 1 for females) is associated with lower sleep quality scores. In contrast, age (B = 0.003, p = 0.913) and marital status (B = -0.019, p = 0.468) did not significantly impact sleep quality in this model.

**Physical Activity Levels:** Neither strenuous (B = 0.027, p = 0.503) nor moderate exercise (B = 0.078, p = 0.053) showed a significant predictive value for sleep quality at conventional levels. However, moderate exercise approached significance, suggesting a potential positive trend that could be explored in future studies.

**Interaction Effects:** The interaction term between age and strenuous exercise (B = 0.026, p = 0.291) also did not reach statistical significance, indicating that the effect of strenuous exercise on sleep quality does not vary by age within this sample.

These findings suggest that while physical activities alone do not significantly predict sleep quality, gender differences play a critical role, possibly due to underlying biological or social factors in-fluencing sleep patterns. The almost significant influence of moderate exercise warrants further investigation, as it might indicate a dose-dependent relationship where milder forms of exercise could positively affect sleep quality, a hypothesis to be tested in further research.

These regression findings provide valuable insights into the complex interactions and influences among physical activity, demographic factors, and their collective impact on sleep quality. The significant role of gender indicates the necessity for gender-specific analyses in future sleep research, especially in the context of lifestyle and physiological considerations.

### Relationship between Sleep Satisfaction and Physical Activities

K-Means cluster analysis was performed to examine how changes in physical activity levels were associated with differences in sleep quality across sample sizes. As detailed in Table 3, depict the segmentation of the study population into two distinct clusters based on their physical activity levels, and overall sleep quality. This analysis illustrates the relationship between physical activity levels and sleep quality across different subgroups within the dataset.

**Table 3:** K-Means Clustering Results on Physical Activity, Gender, and Sleep Quality

| Cluster Attributes | Cluster 1 | Cluster 2 |
|---|---|---|
| Strenuous Exercise (Q2) | 2 | 6 |
| Moderate Exercise (Q3) | 2 | 6 |
| Overall Sleep Quality | -0.05237 | 0.15785 |

A significant difference in physical activity levels between the clusters was observed. Cluster 1 represents a group with lower engagement in physical activities (both strenuous and moderate exercise scores of 2), whereas Cluster 2 includes individuals who participate more frequently in such activities (scores of 6). The sleep quality scores also differ markedly between the two clusters. Cluster 1, which engages less in physical activity, shows a negative sleep quality score (-0.05237), suggesting poorer sleep outcomes. Conversely, Cluster 2, with higher activity levels, exhibits a positive sleep quality score (0.15785), hinting at better sleep conditions.

The data suggest that increased physical activity is associated with improved sleep quality, supporting the notion that lifestyle modifications could be beneficial in enhancing sleep health. The findings from this analysis can be instrumental in developing targeted interventions aimed at promoting physical activities as a means to improve sleep quality.

## Discussion

The primary aim of this research was to investigate the determinants of physical activity and sleep quality among the elderly population, with the goal of developing targeted interventions to promote active lifestyles. So the final goal was to investigate how these factors contribute to overall health in older adults.

Our study observed a significant relationship between sleep satisfaction and physical activity levels among the elderly population. Specifically, we found that individuals with higher levels of physical activity reported better sleep quality, supporting the hypothesis that engagement in regular physical exercise is associated with improved sleep outcomes. This observation aligns with the findings of Banno et al, who demonstrated that exercise improves sleep quality across various populations, and Kline et al, indicating a dose-response effect of exercise on sleep quality in postmenopausal women (10,11) Moreover, Bei et

al emphasized the variability in sleep/wake patterns, which can be influenced by consistent physical activity (9). These findings reinforce the notion that physical activity can serve as a non-pharmacological intervention for enhancing sleep quality in aging populations.

Previous research has shown that both physical activity and sleep are critical determinants of overall health and well-being. For instance, Haddad et al demonstrated through their research that physical exercise significantly improves sleep quality in elderly adults, highlighting the role of physical activities in preventing sleep disorders and promoting general health (13). Additionally, Sadaqa et al on their research emphasizes that regular physical activity not only improves physical health but also contributes to better sleep patterns, particularly in older adults (14). Furthermore, Wu and colleagues (2023) explored how sleep and physical activity interact to influence cognitive function and overall health, reinforcing the idea that these two factors are interrelated and critical for maintaining well-being in aging populations (15). However, despite these insights, there remains limited exploration of the specific relationship between these variables in elderly populations. Studies such as those by Vaingankar et al and Park have highlighted the independent importance of sleep and physical activity but have not fully elucidated their interrelationship in older adults (1, 3). Most existing studies have focused on general adult populations, leaving a gap in understanding how physical activity and sleep quality interact specifically among older adults.

When compared to previous studies, our findings contribute a more nuanced understanding of the relationship between sleep and physical activity in the elderly. Previous research by Vanderlinden et al confirmed that physical activity significantly improves sleep quality across various populations, particularly in postmenopausal women, which aligns with our findings on the positive effects of moderate exercise on sleep quality (16). Similarly, Silva et al demonstrated a dose-response relationship between physical activity and sleep, supporting our observation that in-

creased physical activity correlates with better sleep outcomes (13). Alnawwar et al further highlighted that regular physical exercise is crucial for enhancing sleep quality in the elderly, reinforcing the importance of physical activity as a non-pharmacological intervention for sleep improvement (17).

In addition, both sleep duration and physical activity independently contribute to better mental and physical health, which complements our findings on their combined effects in older adults (2). Research by Hirshkowitz et al established foundational sleep guidelines, emphasizing the significance of sufficient sleep for maintaining cognitive and physical health (12). Likewise, consistent physical activity leads to improved sleep patterns, particularly in older adults, which supports our conclusion that physical activity is a key determinant of sleep satisfaction in this demographic(14).

This research is particularly important because it sheds light on the interconnectedness of sleep quality and physical activity in the elderly, a demographic that is often at higher risk for both sleep disturbances and physical inactivity. Understanding these relationships is critical for developing interventions that can simultaneously address both sleep and physical health, thereby improving the overall quality of life for older adults. Interestingly, our findings challenge the notion that sleep and physical activity are independent factors in the elderly population. Instead, the significant relationship observed between these variables suggests that interventions aimed at improving one may beneficially impact the other, contradicting earlier assumptions of their independence in this age group.

The study provides robust data supporting the relationship between physical activity and sleep satisfaction among the elderly. The results from our regression and cluster analyses indicate that higher physical activity levels are associated with better overall sleep quality, particularly in moderate exercise contexts. This supports the development of targeted interventions that encourage physical activity as a means to enhance sleep satisfaction.

The findings of this study have practical applications for the development of targeted interventions aimed at promoting active lifestyles among the elderly population. Health professionals can use this information to design programs that encourage regular physical activity, which in turn, may lead to improvements in sleep quality and overall well-being.

The novelty of this study lies in its focus on the elderly population and the exploration of the relationship between sleep satisfaction and physical activity, an area that has not been extensively studied in previous research. Our findings contribute to a growing understanding of how these factors interact, particularly in aging populations. However, the study does have limitations. The sample size, while substantial, may not fully capture the diversity of the elderly population, and the cross-sectional design limits the ability to infer causality. These factors should be considered when generalizing the findings to broader populations. Besides, there is the potential for self-report bias in the questionnaire data and the cross-sectional nature of the study, which may affect the generalizability of the findings. Future research should consider longitudinal studies to better establish causal relationships.

## Conclusion

Critical insights are provided into the interrelationship between sleep quality and physical activity in the elderly population, highlighting the significant influence of physical activity on sleep satisfaction. Higher levels of physical activity, particularly moderate exercise, are associated with improved sleep quality, reinforcing the importance of an active lifestyle for healthy aging. Additionally, gender differences were noted, with females generally reporting lower sleep quality. These results underscore the need for targeted interventions that promote physical activity as a mean to enhance sleep and overall well-being in older adults.

The study contributes to existing literature by understanding how different dimensions of sleep

quality interact with various types of physical activity in the elderly. Promoting physical activity in older adults is a viable strategy for improving sleep quality and, by extension, enhancing overall health. These findings have significant implications for public health initiatives aimed at mitigating the risks associated with aging, highlighting the importance of integrating sleep and physical activity into holistic approaches to healthy aging.

## Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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## Conflict of interest

The authors declare that there is no conflict of interest.

## References

1. Vaingankar JA, Müller-Riemenschneider F, Chu AH, et al (2020). Sleep duration, sleep quality and physical activity, but not sedentary behavior, are associated with positive mental health in a multi-ethnic Asian population: A cross-sectional evaluation. *Int J Environ Res Public Health*, 17(22):8489.
2. Liu Y, Wheaton AG, Croft JB, et al (2018). Relationship between sleep duration and self-reported health-related quality of life among US adults with or without major chronic diseases, 2014. *Sleep Health*, 4(31), 265–272.
3. Park S, Cho MJ, Chang SM, et al (2010). Relationships of sleep duration with sociodemographic and health-related factors, psychiatric disorders and sleep disturbances in a community sample of Korean adults. *J Sleep Res,* 19(4):567-77.
4. Park S (2014). Associations of physical activity with sleep satisfaction, perceived stress, and problematic Internet use in Korean adolescents. *BMC Public Health,* 14:1143.
5. Kirkcaldy BD, Shephard RJ, Siefen RG (2002). The relationship between physical activity and self-image and problem behaviour among adolescents. *Soc Psychiatry Psychiatr Epidemiol*, 37(11):544-50.
6. Heidarzadeh E, Rezaei M, Haghi MR, Shabanian H, Lee Y (2021). Assessing the impact of outdoor activities on mental wellbeing; focusing on the walking path in urban area. *Iran J Public Health,* 50(10):2132-38.
7. Yi ES, Rezaei M, Byun H, Jeon S (2024). Factors Shaping Exercise Patterns and Health Status among the Elderly in Aging Nations: A South Korean Perspective. *Iran J Public Health*, 8;53(4):895-903.
8. Jin Y, Jones-Smith JC (2020). Associations between family structure changes and children's physical activity: the mediating role of family income. *BMC Public Health*, 20, 1746.
9. Bei B, Wiley JF, Trinder J, Manber R (2016). Beyond the mean: a systematic review on the correlates of daily intraindividual variability of sleep/wake patterns. *Sleep Med Rev*, 28, 108-124.
10. Kline CE, Sui X, Hall MH, et al (2018). Dose-response effects of exercise training on the subjective sleep quality of postmenopausal women: exploratory analyses of a randomized controlled trial. *BMJ Open*, 2(4), e000343.
11. Banno M, Harada Y, Taniguchi M, et al (2018). Exercise can improve sleep quality: a systematic review and meta-analysis. *Peer J,* 6:e5172.
12. Hirshkowitz M, Whiton K, Albert SM, et al (2015). National Sleep Foundation's sleep time duration recommendations: methodology and results summary. *Sleep Health*,1;1(1):40-3.
13. Silva VP, Silva MP, Silva VL, et al (2022). Effect of physical exercise on sleep quality in elderly adults: a systematic review with a meta-

analysis of controlled and randomized studies. *J Ageing Longev*, 2(2):85-97.

14. Sadaqa M, Németh Z, Makai A, Prémusz V, Hock M (2023). Effectiveness of exercise interventions on fall prevention in ambulatory community-dwelling older adults: a systematic review with narrative synthesis. *Front Public Health*, 11:1209319.

15. Wu D, Qu C, Huang P, et al (2024). Better Life's Essential 8 contributes to slowing the biological aging process: a cross-sectional study based on NHANES 2007–2010 data. *Front Public Health*, 12:1295477.

16. Vanderlinden J, Boen F, Van Uffelen JG (2020). Effects of physical activity programs on sleep outcomes in older adults: a systematic review. *Int J Behav Nutr Phys Act*, 17(1):11.

17. Alnawwar MA, Alraddadi MI, Algethmi RA, Salem GA, Salem MA, Alharbi AA (2023). The effect of physical activity on sleep quality and sleep disorder: a systematic review. *Cureus*,15(8):e43595.