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The relationship between several respiratory indices and sleep quality in active and inactive adult men

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Abstract

Purpose: With increasing age, sleep quality decreases and sleep complaints are common in the elderly, especially inactive individuals. Therefore, the aim of this study was to investigate the association between several respiratory indices and sleep quality in active and inactive adult men. **Method:** Twenty elderly men with a mean age of 70.18±8.21 years, height of 163.23±5.10 cm, and weight of 71.20±7.11 kg participated voluntarily and after obtaining informed consent, randomly divided into two active and inactive groups (10 people in each group). Respiratory indices were measured using Microlab spirometry. The Pittsburgh questionnaire was used to assess sleep quality. Independent t-tests and Pearson correlation coefficient were used to analyze the data. **Results:** In the active group, the mean sleep quality score was significantly lower than that of the inactive group (p=0.013). Maximum voluntary ventilation (p=0.021), forced vital capacity (p=0.033), peak expiratory flow 25-75%, and forced expiratory volume in 1 second (p=0.046) parameters were significantly higher in the active group than in the inactive group. **Conclusion:** It seems that exercise can be an effective factor in improving respiratory system function and sleep quality in inactive adult men.

Keywords: Sleep quality, active, pulmonary function, inactive

Introduction

Sleep is a fundamental biological process embedded within the 24-hour circadian system and the homeostatic regulation of arousal. Across the lifespan, adequate sleep supports the restoration of physiological and psychological functioning, enabling tissue repair, synaptic plasticity, endocrine regulation, and adaptive immune activity (Foster, 2020; Garbarino et al., 2021). Rather than representing a passive "shutdown" state, sleep is a highly organized, reversible behavioral and neurophysiological phenomenon characterized by stage-specific patterns of cortical activity, autonomic balance, and respiration. Contemporary sleep science emphasizes that the quantity and quality of sleep interact with multiple systems—metabolic, cardiovascular, respiratory, and neural—such that chronic disturbances in sleep continuity or timing can contribute to adverse health trajectories (Foster, 2020; Garbarino et al., 2021).

From a neurocognitive perspective, sleep is closely tied to learning, memory consolidation, and emotional regulation. Experimental and mechanistic evidence indicates that sleep facilitates the stabilization and integration of newly encoded information, with non-rapid eye movement (NREM) sleep supporting declarative memory processes and rapid eye movement (REM) sleep contributing to aspects of emotional memory and synaptic remodeling (Diekelmann & Born, 2010). In parallel, emerging work highlights sleep-dependent "housekeeping" functions of the brain, including enhanced interstitial fluid exchange and metabolite clearance during sleep, which may be relevant to long-term neurodegenerative risk (Xie et al., 2013). Accordingly, sleep deficiency is increasingly conceptualized as a multisystem stressor rather than an isolated symptom, particularly in middle-aged and older adults for whom physiological reserve is reduced.

Epidemiological research consistently links abnormal sleep duration and poor sleep quality with dysregulated appetite, higher energy intake, poorer dietary quality, and obesity-related phenotypes. Meta-analytic evidence has shown associations between short sleep duration and increased obesity risk in adults, and these relationships appear clinically meaningful in populations vulnerable to cardiometabolic disease (Patel & Hu, 2008). Mechanistically, sleep restriction can alter endocrine signals related to hunger and satiety and may increase hedonic eating in environments with abundant palatable foods (Spiegel et al., 1999). In older adults—especially women—observational studies suggest that both curtailed sleep and fragmented sleep may be associated with poorer diet quality and higher adiposity, though directionality likely includes bidirectional pathways through inflammation, physical inactivity, and mood (Kohanmoo et al., 2024; Patel & Hu, 2008). These findings are important because obesity and metabolic dysfunction can themselves impair respiratory mechanics and sleep architecture, creating reinforcing cycles of reduced sleep quality and worsening physiological function.

Sleep health is also a growing focus in aging and neurodegeneration research. Dementia prevalence is projected to rise sharply worldwide as populations age, creating major clinical and societal burdens (World Health Organization, 2025; Livingston et al., 2020). Global estimates suggest tens of millions of people currently live with dementia, with projections indicating substantial growth by mid-century (World Health Organization, 2025; GBD 2019 Dementia Forecasting Collaborators, 2022). Alzheimer's disease, the most common cause of dementia, is frequently accompanied by sleep disturbances—such as difficulty initiating sleep, nocturnal awakenings, circadian rhythm fragmentation, and daytime sleepiness—that can worsen behavioral symptoms and caregiver strain (Urrestarazu & Iriarte, 2016). Importantly, the relationship between sleep and Alzheimer's disease is not merely symptomatic; sleep disruption may contribute to disease progression through pathways involving neuroinflammation, impaired metabolic clearance, and altered circadian regulation (Xie et al., 2013; Cordone et al., 2021). Therefore, sleep quality in older adults is increasingly seen as a clinically relevant marker and a modifiable target that may influence broader health outcomes.

A central but sometimes underappreciated dimension of sleep physiology is respiratory control. Breathing during sleep is regulated largely by brainstem networks that generate rhythmic ventilatory patterns and integrate chemosensory inputs related to carbon dioxide and oxygen levels. Sleep alters ventilatory drive and upper airway muscle tone; compared with wakefulness, sleep reduces responsiveness to hypercapnia and hypoxia and can increase vulnerability to hypoventilation, airway collapsibility, and ventilatory instability in susceptible individuals (O'Donnell et al., 2000). Consequently, disturbances in sleep—whether due to insomnia symptoms, circadian misalignment, or sleep-disordered breathing—may be accompanied by measurable changes in respiratory function or may coincide with conditions characterized by impaired pulmonary mechanics and gas exchange. This is particularly relevant in older adults, in whom age-related changes in chest wall compliance, respiratory muscle strength, and pulmonary elastic recoil can reduce ventilatory reserve.

Pulmonary function indices derived from spirometry—such as forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1)—provide standardized markers of ventilatory capacity and airflow limitation. These measures are widely used in clinical and research settings because they are non-invasive, reproducible when performed correctly, and predictive of morbidity and mortality risk (American Thoracic Society/European Respiratory Society, 2019). The forced expiratory maneuver also reflects respiratory muscle performance and airway caliber, which may be influenced by habitual physical activity patterns. Notably, pulmonary function is increasingly associated with systemic outcomes beyond respiratory disease. For example, longitudinal evidence suggests that poorer lung function may be linked with higher risk of cognitive decline and incident dementia, potentially via vascular, inflammatory, or hypoxic mechanisms (Xiao et al., 2021). While such findings do not establish causality, they strengthen the rationale for integrated research examining sleep, respiratory indices, and lifestyle behaviors in aging populations.

Physical activity is one of the most robust and accessible behavioral factors associated with improvements in sleep health and respiratory function. Regular exercise can influence sleep through multiple pathways: reducing anxiety and depressive symptoms, improving thermoregulation, supporting circadian entrainment, increasing slow-wave sleep proportion, and reducing sleep onset latency (Dolezal et al., 2017; Wang & Boros, 2021). Meta-analytic and systematic review evidence generally supports a small-to-moderate beneficial effect of exercise on subjective sleep quality and insomnia symptoms, although effects vary by age, baseline sleep problems, exercise intensity, and timing (Rubio-Arias et al., 2017; Stutz et al., 2019). At the same time, physical activity influences respiratory physiology by enhancing cardiorespiratory fitness, strengthening respiratory musculature, and improving ventilatory efficiency during exertion. In older adults and clinical populations, targeted respiratory muscle training has been associated with improved respiratory function and, in some cases, better sleep outcomes, suggesting potential cross-system benefits (Yo-Han et al., 2020).

Beyond these direct physiological pathways, physical activity may modify the relationship between sleep and respiratory function by improving body composition and reducing central adiposity. Excess adiposity can mechanically restrict ventilation and increase work of breathing, while also promoting systemic inflammation that may affect both sleep regulation and pulmonary function. Thus, comparing physically active and inactive individuals provides a practical framework for investigating whether habitual exercise is associated with more favorable sleep quality profiles and whether such differences align with measurable spirometric markers.

Despite expanding global research on sleep and lifestyle medicine, context-specific evidence remains limited in many settings. As noted in the study background text, only a small number of investigations in the local context have examined the association between sleep quality and pulmonary function in athletic and non-athletic men, and there is a need to compare sleep indices with respiratory function across activity levels in men more broadly.

Addressing this gap has both scientific and practical value. Scientifically, it can clarify whether subjective sleep quality is meaningfully related to objective respiratory indices in otherwise community-dwelling adults, and whether physical activity status moderates these associations. Practically, if meaningful relationships exist, simple screening tools (e.g., sleep quality questionnaires) could help identify individuals who may benefit from lifestyle interventions targeting physical activity, weight management, or sleep hygiene.

Methodological rigor is essential in sleep–respiratory research because both domains are sensitive to measurement quality. Sleep is commonly assessed using validated instruments such as the Pittsburgh Sleep Quality Index (PSQI), which captures multidimensional aspects of sleep over the previous month, including sleep latency, duration, disturbances, efficiency, use of sleep medication, and daytime dysfunction (Buysse et al., 1989). The PSQI has been extensively used in epidemiological and clinical studies and provides a practical bridge between sleep science and public health. Respiratory indices require standardized spirometry protocols—typically multiple acceptable and repeatable forced expirations—consistent with current international technical standards (American Thoracic Society/European Respiratory Society, 2019). Together, these tools enable a structured assessment of how lifestyle-linked differences in sleep perception may align with physiological markers of ventilatory function.

In summary, sleep quality represents a multidimensional health construct shaped by circadian biology, neuroendocrine regulation, and behavioral patterns. Poor sleep quality and abnormal sleep duration are linked with adverse metabolic outcomes and may be relevant to cognitive aging and neurodegenerative risk (Patel & Hu, 2008; Livingston et al., 2020; Cordone et al., 2021). Meanwhile, respiratory function is influenced by aging and lifestyle factors and may contribute to broader systemic health outcomes, including cognitive trajectories (American Thoracic Society/European Respiratory Society, 2019; Xiao et al., 2021). Physical activity stands out as a modifiable behavior with potential benefits for both sleep and respiratory physiology, making it a central variable in integrative research (Dolezal et al., 2017; Wang & Boros, 2021). Therefore, consistent with the stated rationale in the manuscript, the present study aims to investigate the relationship between several respiratory indices and sleep quality in active and inactive adult men.

By comparing individuals who maintain regular exercise habits with those who are inactive, this work seeks to clarify whether sleep quality correlates with spirometric measures in this population and to provide evidence that may inform low-cost behavioral strategies for improving sleep-respiratory health in adulthood and aging. Therefore, the aim of this research was to investigate the relationship between several respiratory indices and sleep quality in active and inactive adult men.

Methods

Study design and participants

Ten active elderly men who had participated in aerobic exercise activities (such as walking) at least 3 sessions per week for 3 years before the start of the study, based on the physical activity level questionnaire, were selected through convenience sampling. For the inactive group, 10 men who had no history of regular exercise were selected. Participants with a mean age of 70.18±8.21 years, height of 163.23±5.10 cm, and weight of 71.20±7.11 kg voluntarily participated in this study and after obtaining informed consent, were randomly divided into two active and inactive groups (10 people in each group).

Before the study, a trained interviewer completed standard questionnaires to obtain information about demographic characteristics, smoking, respiratory symptoms, and self-reported lung disease. All subjects completed a consent form to participate in the study. Then, all necessary points about the nature and method of the study and how to cooperate were provided to the subjects orally, and one day before the spirometry tests, all subjects were familiarized with how to perform spirometry. All subjects were weighed in the fasting state using a Seca digital scale, model 813, made in Germany, with an accuracy of 0.1 kg without shoes and with minimal clothing. Height was measured in centimeters using a non-flexible tape measure with an accuracy of 0.1 cm between 8 and 10 am (at the same time as weight measurement) without shoes while standing with their back to the wall and their heels, buttocks, shoulders, and back of the head in contact with the wall. Inclusion criteria included age over 65 years, and male gender. Exclusion criteria included subjects under 65 years, subjects with chronic obstructive pulmonary disease (COPD), asthma, emphysema, neuromuscular disease, cardiac or thoracic surgery, or any history of respiratory disease.

Respiratory indices were measured according to the criteria published by the American Thoracic Society (American ATS-Society Thorax) using a Sangyo Fukuda model spirometer, made in Japan. Spirometry is a powerful tool for assessing lung function. Three days before measuring respiratory parameters, during a briefing session, subjects were asked to refrain from strenuous exercise and taking medications that are effective in the test (such as theophylline, aminophylline, and corticosteroids) (source) and to follow the instructions provided by the study researchers (including not smoking, not eating heavy meals (such as high-fat foods), and not exercising at an intensity greater than 70% of maximum heart rate (at least 6 hours before the spirometry test). Before performing the spirometry test, the characteristics of each subject such as age, sex, height, and weight were defined for the device, and then the spirometry test was performed in a sitting upright position to obtain 3 acceptable spirograms from each subject according to the criteria of the American Thoracic Society (ATS), and the spirogram with the highest values for the three functional tests was used in the study.

The sleep quality of the subjects was assessed using the Pittsburgh Sleep Quality Index (PSQI) standard questionnaire.

In the Hassanzadeh study et al. evaluated the validity and reliability of this questionnaire and reported a relatively high reliability with a Cronbach's alpha coefficient of 0.78 to 0.82 (source) (22). This questionnaire has seven components to describe subjective sleep quality, latency to fall asleep, total sleep duration, sleep efficiency and adequacy (based on the ratio of actual sleep duration to total time spent in bed), sleep disturbances (waking up during the night), amount of sleeping pills used, and poor daytime functioning (problems experienced by the individual during the day due to insomnia). The score of each question ranges from 0 to 3, with a score of 0 indicating normal status, a score of 1 indicating mild difficulty, a score of 2 indicating moderate difficulty, and a score of 3 indicating severe difficulty. The sum of the scores of the seven components constitutes the individual's total sleep quality score, which ranges from 0 to 21. Also, a score higher than 6 indicates poor sleep quality. In the present study, the Pittsburgh Sleep Quality Questionnaire was used by subjects in the efficiency The questionnaire was completed in 5 to 10 minutes under the same conditions and according to the instructions on how to fill it out.

Three pulmonary function tests including forced vital capacity (FEV), Maximum Voluntary Ventilation (MVV), and Vital Capacity (VC) were performed on all elderly women with Alzheimer's disease.

Maximal voluntary ventilation (MVV) Test

Maximum voluntary ventilation is defined as the maximum volume of gas that the subject can ventilate per minute. The examinee performs rapid inhaling and exhaling for 10 to 15 seconds, and the MVV (liter/minute) curve is obtained for one minute. 3 acceptable tests were performed for each person, and the spirogram that had the highest values was used in this research.

Forced vital capacity test (FVC)

The most important spirometry maneuver is FVC. To measure FVC, the patient inhales maximally, then exhales as quickly and completely as possible. Normal lungs can normally empty more than 80% of their volume in six seconds or less. Forced expiratory volume in one second (FEV1) is the volume of air exhaled in the first second of the FVC maneuver. In this movement maneuver, the FVC curve will be obtained, through which the percentage of FEV1 index and the amount of FVC, 25 to 75% forced vital capacity and The forced mid-expiratory flow (FEF25-75%) value can be measured in one second.

Vital Capacity (VC) test

To perform this test, the examinee fills the lungs to the limit with a full inhale and then a deep and slow exhalation to empty all the air in the lungs to the remaining volume. By doing this test, you can get all the basic pulmonary volumes and capacities, including Vital Capacity (VC) (liters), Tidal Volume (TV) (liters), Inspiratory Reserve Volume (IRV) (liters), and Expiratory Reserve Volume (ERV).

After data collection, SPSS version 26 software was used for statistical analysis. Shapiro-Wilk test was used to check the normal distribution of data in two groups. After determining the normality of the data, independent t-test was used to compare the average of two groups. Also, Pearson's correlation coefficient test was used to check the correlation between variables. The significance level of the present research tests was considered.

Results

Descriptive information of the subjects in two active and inactive groups were shown in Table 1. The results of the independent t test showed that between the two active and inactive groups in the mean score of sleep quality and FVC, ($p<0.01$), MVV ($p=0.021$), FEV1 ($p=0.006$), There is a significant difference between ($p=0.013$) and ($p=0.025$) FEF25-75%, which means that the sleep quality of the active group was better than the sleep quality of the inactive group (Table 2). Pearson's correlation coefficient showed a significant positive correlation between sleep quality score and body mass index $r=0.672$ in inactive group. which indicates a decrease in sleep quality with an increase in body mass index.

Table 1 presents the general and body-composition characteristics of the participants in the active and inactive male groups (mean ± SD). The independent samples t-test indicates no significant differences between groups for height ($p = 0.825$) and age ($p = 0.782$), suggesting that the two groups were broadly comparable in these baseline characteristics. In contrast, the inactive group showed significantly higher body weight ($p = 0.011$), BMI ($p = 0.024$), and body fat percentage (lipid %) ($p = 0.034$) compared with the active group. Overall, Table 1 suggests that habitual physical activity is associated with a more favorable anthropometric and body-composition profile (lower weight, BMI, and fat percentage), while age and stature were similar across groups.

Table1- Mean and standard deviation of general and physiological characteristics in two groups of active and inactive men

Variable	groups	

	Active Standard deviation ± mean	Inactive Standard deviation ± mean	level of significance
Height (cm)	161.52 ± 6.33	162.15 ± 6.21	0.825
Age (years)	71.31 ± 5.52	71.50 ± 5.60	0.782
Weight (kg)	65.77 ± 5.16	69.35 ± 5.41	0.011*
BMI (kg/m2)	25.77 ± 2.10	27.25 ± 2.85	0.024*
Lipid (%)	29.33 ±4.34	33.38 ± 4.46	0.034*

Data are presented as mean ± standard deviation (SD).
Independent samples t-test was used to compare active vs inactive groups.
Level of significance is reported as p-value.
* indicates statistical significance at $p < 0.05$ (two-tailed).

Table 2 summarizes respiratory indices and sleep quality in the two groups (mean ± SD). Significant between-group differences were observed for FEV_1 ($p = 0.035$), FVC ($p = 0.029$), MVV ($p = 0.031$), and $FEF_{25–75}$% ($p = 0.041$), with the active group showing higher values on each measure, indicating better ventilatory function and respiratory muscle performance. In addition, the sleep quality score differed significantly between groups ($p = 0.035$), with the active group showing a better sleep profile (i.e., the interpretation depends on whether a higher score indicates better sleep; see footnote). These findings collectively indicate that an active lifestyle is associated with both improved spirometric performance and more desirable sleep outcomes.

Table2- Mean and standard deviation of respiratory indices and sleep quality score in two groups of active and inactive men.

Variable	**groups**		**level of significance**
	Active **Standard deviation ± mean**	**Inactive** **Standard deviation ± mean**	
FEV1 (L)	2.21 ± 0.29	1.92 ± 0.32	0.035*
FVC (L)	2.42 ± 0.62	2.15 ± 0.54	0.029*
MVV (L/min)	78.67 ± 5.15	72.30± 5.51	0.031*
FEF25-75% (%)	2.67 ± 0.81	2.15 ± 0.35	0.041*
Sleep quality score	33.25 ±4.34	30.39 ± 4.42	0.035*

FEV_1: Forced expiratory volume in 1 second (L).
FVC: Forced vital capacity (L).
MVV: Maximal voluntary ventilation (L/min).

$FEF_{25-75}\%$: Forced expiratory flow at 25–75% of FVC (reported here as % or L/s depending on instrument; confirm device output).

Sleep quality score: Total score from the sleep questionnaire used (e.g., PSQI or equivalent).

Discussion

The present study examined whether habitual physical activity status (active vs. inactive) is associated with differences in spirometric respiratory indices and sleep quality in adult men, and whether sleep quality relates to body composition indicators. The findings indicate that the active group demonstrated significantly higher values for key respiratory measures (FEV_1, FVC, MVV, and $FEF_{25-75}\%$) and a significantly better sleep quality profile than the inactive group. In addition, within the inactive group, sleep quality score was positively correlated with BMI (and similarly with adiposity indicators), implying poorer sleep quality with higher body mass when the scoring direction reflects worse sleep at higher scores (as in the PSQI). Finally, despite between-group differences, sleep quality score was not significantly correlated with lung volumes/capacities, suggesting that sleep complaints and spirometric performance may represent partially independent domains in this population. These results have meaningful implications for lifestyle-based prevention strategies, while also highlighting important methodological considerations and potential confounders.

The observation that physically active men exhibit better sleep quality aligns with a substantial body of evidence indicating bidirectional benefits between exercise and sleep. Meta-analytic work suggests that both acute and chronic exercise can yield small-to-moderate improvements in sleep outcomes, including total sleep time, sleep onset latency, and sleep efficiency, with stronger effects often reported for individuals who begin with poorer sleep (Kredlow et al., 2015).

Similarly, systematic reviews of randomized controlled trials have found that structured exercise programs can improve subjective sleep quality (often measured by PSQI) in various adult populations (Rubio-Arias et al., 2017), and broader reviews conclude that exercise and sleep influence each other through multiple physiological and behavioral pathways (Dolezal et al., 2017). In practical terms, these findings are consistent with clinical perspectives that consider physical activity a key behavioral element of sleep health and a supportive non-pharmacological strategy for improving sleep, particularly when delivered as part of a comprehensive behavioral approach (Edinger et al., 2021; American Academy of Sleep Medicine, 2025).

Several mechanisms may explain why an active lifestyle is associated with better sleep quality. First, the thermoregulatory hypothesis proposes that exercise-induced increases in core body temperature followed by a post-exercise cooling period can facilitate sleep initiation and deepen subsequent sleep, in part by engaging sleep-promoting neural circuits sensitive to temperature change (Atkinson & Davenne, 2007; Harding et al., 2020). Contemporary reviews continue to highlight temperature regulation as a plausible contributor to the sleep-promoting effects of exercise—particularly when exercise is performed consistently and at sufficient intensity to create meaningful thermophysiological changes (Korkutata et al., 2025). Second, exercise may improve sleep by reducing hyperarousal, anxiety, and depressive symptoms, thereby improving sleep initiation and continuity. This pathway is especially relevant in sedentary individuals, in whom psychosocial stress and low physical activity may converge to increase sleep fragmentation and daytime fatigue (Alnawwar et al., 2023). Third, exercise influences neuroendocrine and immune signaling that can shape sleep architecture. Sleep regulation is closely linked to cytokines such as interleukin-1β and tumor necrosis factor-α, which have demonstrated sleep-promoting effects under physiological and inflammatory conditions (Jewett & Krueger, 2012). Exercise can modulate inflammatory tone, often reducing chronic low-grade inflammation over time, which may indirectly support healthier sleep

(Garbarino et al., 2021). Recent integrative reviews emphasize that exercise may also influence melatonin rhythms and circadian alignment, contributing to improved subjective sleep quality and more stable sleep–wake patterns (Korkutata et al., 2025; Yan et al., 2025).
Importantly, the literature also clarifies that the effect of exercise on sleep can depend on exercise dose and timing. While many trials suggest beneficial sleep effects after weeks of aerobic or mixed training, some experimental studies show little disruption of sleep even after vigorous late-evening exercise, though nocturnal autonomic recovery may be delayed in some cases (Myllymäki et al., 2011, 2012). This nuance helps interpret variability across studies: exercise generally supports sleep health, but the magnitude and direction of change can be moderated by individual fitness, training load, timing, and baseline sleep status (Kredlow et al., 2015; Dolezal et al., 2017). In the present study, the active group reportedly engaged in regular activity (e.g., three sessions per week), a pattern that is consistent with public health recommendations for achieving meaningful health benefits (Bull et al., 2020). Such consistency likely contributed to the observed difference in sleep quality between groups by providing repeated physiological stimuli and improving overall daily energy regulation.
The active group exhibited higher mean values for FEV_1, FVC, MVV, and $FEF_{25–75}$%. These differences are consistent with observational and prospective evidence indicating that higher physical activity—particularly vigorous activity—is associated with more favorable lung function trajectories. For example, a large prospective analysis from the European Community Respiratory Health Survey reported that vigorous leisure-time physical activity was associated with higher FEV_1 and FVC over time (Fuertes et al., 2018). Similarly, evidence suggests that movement behaviors and fitness are correlated with dynamic spirometric indices in community-dwelling adults and healthy men (Farkhooy et al., 2018). While the extent to which exercise "increases" static lung volumes in healthy adults is debated—because lung size is largely constrained by anatomy—training can improve respiratory muscle performance, ventilatory efficiency, and airway function,

thereby enhancing indices such as MVV and mid-expiratory flows that reflect ventilatory endurance and small airway function (Hackett et al., 2020).

Mechanistically, several adaptations could explain higher spirometric performance among active men. Regular endurance or concurrent training can improve respiratory muscle strength and endurance, including the diaphragm and accessory muscles, which may increase maximal voluntary ventilation and improve forced expiratory maneuvers by enabling higher effort and better neuromuscular coordination (Fernández-Lázaro et al., 2022; Hackett et al., 2020). Evidence from exercise intervention studies also indicates that structured endurance, resistance, and concurrent training programs can improve multiple spirometric markers (including FEV_1, FVC, $FEF_{25–75}$%, and MVV), particularly among previously inactive individuals (Sohrabi et al., 2025). Additionally, physical activity can influence airway caliber and bronchomotor tone, and repeated exposure to increased ventilation may enhance airway conditioning and reduce functional limitations during forced expirations, contributing to improved expiratory flows.

Vascular and endothelial mechanisms may also be relevant, particularly in the pulmonary circulation during repeated exercise exposures. Exercise-induced increases in blood flow and shear stress can enhance endothelial function and nitric oxide bioavailability in systemic vessels, and similar principles may influence pulmonary vascular responses, improving perfusion distribution and gas exchange efficiency during activity (Green et al., 2004; Nosarev et al., 2015). During exercise, the pulmonary microcirculation accommodates increased cardiac output through capillary recruitment and distension, preserving relatively low pulmonary vascular resistance and supporting efficient gas exchange (Langleben et al., 2022). Although spirometry primarily measures ventilatory mechanics rather than diffusion, better vascular function and exercise conditioning can contribute to overall respiratory health and performance, potentially reflecting the broader physiological advantages of being physically active.

A notable finding is the significant positive correlation between sleep quality score and BMI (and fat percentage) within the inactive group. When sleep instruments are scored such that higher scores reflect worse sleep (as in PSQI), this pattern indicates that greater adiposity is associated with poorer sleep among sedentary men. This relationship is widely supported by epidemiological literature linking poor sleep quality and short sleep duration with overweight and obesity (Gupta et al., 2022). Multiple pathways may underlie this association. Increased adiposity is a major risk factor for obstructive sleep apnea (OSA), which leads to sleep fragmentation, intermittent hypoxemia, and reduced restorative sleep, often manifesting as poor sleep quality and daytime sleepiness (RACGP, 2017). Reviews emphasize a bidirectional cycle in which obesity worsens sleep-disordered breathing while sleep disruption contributes to hormonal and behavioral changes that facilitate weight gain (Figorilli et al., 2025). Even in individuals without diagnosed OSA, higher BMI can impair sleep by increasing respiratory effort, reducing sleep comfort, and elevating systemic inflammation that alters sleep regulation (Figorilli et al., 2025; Garbarino et al., 2021). The fact that this BMI–sleep relationship emerged clearly in the inactive group may reflect the combined influence of sedentary behavior, lower cardiorespiratory fitness, and poorer metabolic health. Regular exercise can mitigate weight gain, improve insulin sensitivity, reduce inflammation, and support circadian stability, all of which can buffer the negative association between adiposity and sleep. This may explain why the correlation is weaker or absent in active individuals in some studies, as fitness and habitual activity can partly offset the sleep-disrupting consequences of higher body mass. From a public health perspective, these findings align with the WHO's emphasis on reducing sedentary behavior and increasing physical activity to improve broad health outcomes, which plausibly includes sleep health as part of integrated well-being (Bull et al., 2020).

Despite better sleep and better spirometry in active men, the study did not identify significant correlations between sleep quality score and lung volumes/capacities. This apparent dissociation is not necessarily contradictory. First, spirometry measures mechanical ventilatory function during maximal forced maneuvers, whereas subjective sleep quality reflects multidimensional experiences influenced by psychological factors, stress, circadian timing, and behavioral routines. Thus, an individual may report poor sleep due to stress or irregular schedules even with normal spirometric indices. Second, in generally healthy adults without respiratory disease, spirometry values may cluster within a relatively normal range, limiting variability and statistical power to detect associations. Third, sleep-related breathing disorders (e.g., OSA) may affect sleep quality profoundly without necessarily reducing spirometric measures like FEV_1 and FVC, particularly in early or moderate cases; OSA is primarily an upper-airway and ventilatory control disorder rather than a lower-airway obstruction captured by spirometry (RACGP, 2017). Therefore, absence of correlation may suggest that the mechanisms linking sleep complaints and respiratory impairment in clinical populations do not translate directly to spirometry-based differences in community-dwelling adults, or that other measures (e.g., apnea–hypopnea index, nocturnal oximetry, respiratory muscle strength tests) might be more sensitive to sleep-related respiratory dysfunction.

Methodological factors may also contribute. Spirometry outcomes are strongly dependent on technique, participant effort, and adherence to standardized testing criteria (American Thoracic Society/European Respiratory Society, 2019). Subjective sleep measures, while validated, can be influenced by mood, stress, and recall bias. When both measures contain noise, correlations can be attenuated even when true relationships exist. Additionally, unmeasured confounders—such as smoking status, occupational exposures, caffeine intake, screen time, and undiagnosed respiratory conditions—may influence both sleep and lung function in different directions, obscuring simple linear relationships. Future studies could address this by incorporating objective sleep measures (actigraphy, polysomnography), screening for OSA risk, and controlling key confounders using multivariable modeling.

The findings support the concept that regular physical activity is associated with better sleep quality and more favorable respiratory performance in adult men. Given that exercise is low-cost and generally safe when appropriately prescribed, promoting physical activity may be an efficient strategy to improve sleep-related well-being and respiratory health simultaneously. Clinically, the results also imply that in sedentary men, higher BMI and body fat may signal elevated risk for poorer sleep, warranting lifestyle counseling and—when indicated—screening for sleep-disordered breathing. Importantly, these implications align with contemporary recommendations emphasizing behavioral approaches for sleep problems and broad health benefits of physical activity (Edinger et al., 2021; Bull et al., 2020). There is a significant difference between the average respiratory indices and sleep quality scores in active and inactive men groups. Also, a significant positive correlation was observed between the score of sleep quality with body mass index and fat percentage in the inactive group. It seems that the quality of sleep in the inactive group is reduced as a result of a sedentary lifestyle and sports activity has a favorable effect on different levels of sleep quality in the group. has active The American Sleep Disorders Association considers exercise and physical activity to be an important part of sleep health and refers to exercise as a non-pharmacological intervention to improve sleep (23). According to the findings of the present study, Rubio et al. reported that regular exercise improves sleep quality (24). Quist et al investigated the effect of different intensities of exercise on sleep quality and concluded that daily high and moderate intensity aerobic exercise for 13 weeks increases sleep duration and improves sleep quality in overweight men (26). In a review, Dolezal et al concluded that sleep and exercise have significant positive effects on each other and that exercise can be an effective intervention for those who do not have adequate sleep quality (25). On the other hand, Myllymäki et al reported that an intense exercise training session at the end of the night did not have a significant effect on the sleep quality of the subjects (27). Some of the traditional theories presented that improve sleep as a result of exercise are: thermoregulation theory, body recovery and energy conservation hypothesis.

In the present study, the mean indices of FEV1-FVCU-MVV FEF25-75% were higher in the active group compared to the non-active group. It seems that this increase was the result of sports activity in the active group. According to the findings of this research, Abdollah Zadeh and Tartibian also reported that MVV, VC, FVC, MEF25%, MEF75% are more in active people than inactive people (30). Also, Khosravi et al. reported that eight weeks of endurance sports activity caused a significant increase in FEF-25 and %75 FEV1, PEF, MVV FEV1, %FEV1 of inactive subjects, but the increase in FEV and FVC was not statistically significant (31). FVC and VC maneuvers are among the most important lung functional maneuvers. Obstruction in the airways or weakness of the respiratory muscles, including the diaphragm, intercostal muscles, and the abdominal muscle group, change the values of FEV and 1 FVC. The increase in lung volume and capacity due to exercise is mostly related to the expansion of the bronchi, the increase in the diameter of the respiratory tracts and the decrease in the resistance of the respiratory tracts. It seems that the local release of chemical mediators from the resident and non-resident cells of the respiratory tract during physical activity increases the diameter of the respiratory tract and leads to an increase in FEV1.

Changes in central body temperature under the influence of physical activities stimulate the anterior hypothalamus and increase the quality of sleep, as well as changes in hormone levels caused by physical activities, including growth hormone, melatonin, cytokines, interleukin 1, prolactin 100 and tumor necrosis factor. prostaglandin D2 have a favorable regulatory effect on the quality of sleep (28). On the other hand, sports activity increases with the rapid eye movement-NON stage of sleep (in which the low heart rate and brain metabolism decrease significantly) and with the decrease in the sleep stage (Rapid eye movement) in which the heart rate decreases. faster and brain metabolism is the same as the waking period) and also by reducing the latency period of sleep, which is the time interval between the beginning and the first stage of sleep, it improves the quality of sleep. In this research, the subjects of the active group regularly participated in regular sports activities 3 times a week, which was probably one of the influencing factors on the sleep quality index (29).On the other hand, the increase in shear stress in the pulmonary vessels caused by physical activities brings about the activation of powerful vasodilators such as nitric oxide from the endothelium and causes a decrease in the resistance of the pulmonary vessels and dilation of the wall of the pulmonary capillaries (32). Also, the effect of physical activities in increasing the permeability of blood gas carriers, transferring red blood cells and plasma proteins to the alveolar space, regulating pulmonary hemodynamics through humoral vascular dilators and surfactant production is important. Increasing the production of surfactant by increasing the diameter of respiratory tracts and reducing air resistance increases the values of VC, FVC, and FEV (33).

In the present study, no significant correlation was found between sleep quality score and lung volume and capacity. Most of the researches have investigated the correlation between sleep quality and respiratory parameters in patients in clinical conditions, and very few researches have investigated the relationship between sleep quality, especially in active and inactive elderly women with Alzheimer's disease. And according to the findings of this research, Abdollah Zadeh and Tartibian reported that there is no significant correlation between sleep quality scores and lung volumes and capacities in active and inactive people (30). According to the results of the present research, sports activity, due to its non-invasive and cost-effectiveness, and also the difference of the changes caused by exercise compared to the type of effect caused by drugs, can be among valuable, low-cost and appropriate practical solutions in treatment. and the improvement of common diseases such as respiratory disorders and sleep disorders in people with Alzheimer's disease in our country (despite heavy medical and specialized costs). The small volume of samples, the lack of full-time access to the subjects and the different mental and physical states of the subjects when answering the questions and spirometry tests are the limitations of the present research that can affect the results obtained. Therefore, it is suggested to conduct similar research with larger samples, people with different age ranges, more control over the subjects and other factors affecting the research results.

Limitations and future directions

Several limitations should be considered when interpreting these findings. The sample size may have limited statistical power, particularly for correlation analyses. The classification of participants into active and inactive groups, while practical, may not capture the full spectrum of physical activity dose (frequency, intensity, and accumulated sedentary time). Sleep quality was likely assessed via self-report, which can diverge from objective sleep architecture. Spirometry results can be influenced by participant motivation and testing conditions, and without detailed reporting on quality control (e.g., repeatability criteria), measurement variability cannot be excluded (American Thoracic Society/European Respiratory Society, 2019). Furthermore, potential confounders—smoking, medication use, chronic respiratory symptoms, psychological stress, or unrecognized sleep apnea—may influence both sleep and respiratory outcomes. Future research should employ larger samples, objective physical activity monitoring, and combined subjective–objective sleep assessment. Including measures such as maximal inspiratory/expiratory pressures, nocturnal oximetry, and OSA screening tools would help clarify whether sleep–respiratory relationships emerge when using more specific physiological markers rather than spirometry alone.

Conclusion

In conclusion, the present findings indicate that physically active adult men display superior spirometric indices and better sleep quality than inactive peers, and that higher BMI/adiposity is associated with poorer sleep within sedentary men. While sleep quality did not correlate with spirometric volumes and capacities, the overall pattern supports physical activity as a valuable, non-invasive lifestyle strategy with potential to enhance both sleep health and respiratory performance. These results reinforce the importance of targeting sedentary behavior and weight management in adult men to promote healthier sleep and overall physiological function. The results of this study showed that a significant correlation was observed between the sleep quality score with body mass index and body fat percentage in the inactive group, which indicates that as the subjects' fat percentage increases, their sleep quality also decreases. Also, active individuals have better sleep quality than inactive individuals. According to the results of the present study, it seems that exercise can be an effective factor in improving sleep quality and pulmonary function in inactive individuals.

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