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ORIGINAL RESEARCH

# Respiratory Function and Information Processing Speed in Coal Power Plant Workers: Moderating Effects of Physical Activity and Sedentary Behavior

Pill Soo Kim[1,2], Ting-Fu Lai[2,3], Jong-Hwan Park[4–6], Minwoo Jang[2], Yeo-Kyung Shin[2], Du-Ri Kim[2], Il Jae Wang[2,7], Hyuk Jin Choi[1,2,8], Jae-Il Lee[1,2,8]

[1]Department of Neurosurgery, Pusan National University Hospital, Busan, Republic of Korea; [2]Biomedical Research Institute, Pusan National University Hospital, Busan, Republic of Korea; [3]Graduate Institute of Sport, Leisure and Hospitality Management, National Taiwan Normal University, Taipei City, 106, Taiwan; [4]Department of Convergence Medicine, Pusan National University School of Medicine, Yangsan, Republic of Korea; [5]Department of Clinical Bio-Convergence, Graduate School of Convergence in Biomedical Science, Pusan National University School of Medicine, Yangsan, Republic of Korea; [6]Convergence Medical Institute of Technology, Pusan National University Hospital, Busan, Republic of Korea; [7]Department of Emergency Medicine, Pusan National University School of Medicine, Yangsan, Republic of Korea; [8]Department of Neurosurgery, Pusan National University School of Medicine, Yangsan, Republic of Korea

Correspondence: Jae-Il Lee, Email medifirst@pusan.ac.kr

**Background:** In occupational settings like coal power plants, impaired respiratory function and cognitive performance can pose significant risks to worker safety and productivity. This study aimed to investigate the associations between respiratory muscle strength and information processing speed in coal power plant workers, and to explore whether these associations are moderated by physical activity and sedentary behavior.

**Methods:** A cross-sectional study was conducted among 171 coal power plant workers. Respiratory muscle strength was assessed using Maximal Inspiratory Pressure (MIP) and Peak Expiratory Flow (PEF). Information processing speed was evaluated using a validated tablet-based cognitive assessment tool. Physical activity levels and sedentary behavior were assessed using the International Physical Activity Questionnaire (IPAQ). Multiple linear regression analyses were performed to examine the associations between respiratory function and cognitive performance, stratified by physical activity levels and sedentary behavior patterns.

**Results:** After adjusting for covariates, in the active group (≥150 min/week of moderate-to-vigorous physical activity), individuals with MIP <80% showed significantly lower information processing speed scores (B = −6.341, 95% CI: −11.709 to −0.972, p = 0.021) compared to those with MIP ≥80%. Similarly, those with PEF <80% demonstrated significantly lower scores (B = −8.383, 95% CI: −14.601 to −2.165, p = 0.009). In the non-prolonged sedentary group (<9 hours/day), participants with MIP <80% exhibited significantly lower scores (B = −6.655, 95% CI: −11.684 to −1.626, p = 0.010). No significant associations were observed in the inactive or prolonged sedentary groups.

**Conclusion:** The relationship between respiratory muscle strength and information processing speed in coal power plant workers is moderated by physical activity levels and sedentary behavior patterns. These findings highlight the importance of considering occupational factors in health interventions and suggest that promoting physical activity and reducing sedentary time could have multifaceted benefits for this workforce.

**Keywords:** Respiratory function, cognitive performance, coal power plant workers, physical activity, sedentary behavior, occupational health, occupational exposure

## Background

Cognitive function, which includes abilities such as memory, attention, and information-processing speed, is essential for overall well-being and successful aging.[1] Preserving cognitive function is particularly important in adulthood, as it serves as a protective factor against dementia and other neurodegenerative diseases.[2] Information processing speed, a key aspect of cognitive function, reflects the efficiency with which individuals perceive, process, and respond to stimuli.[3] A decline





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in information processing speed has been associated with an increased risk of cognitive impairment,[4] emphasizing the need to understand the factors that may influence this cognitive domain.

Occupational exposures, such as those found in coal power plants, can pose significant risks to workers' health and may affect cognitive function.[5,6] Coal power plant workers are subject to a unique confluence of environmental stressors that can synergistically affect respiratory and cognitive health. Coal dust and ash particles, which contain crystalline silica and metals, are of primary concern.[7] Beyond particulate matter, the work environment presents multiple challenges. Physically demanding tasks, often performed in confined spaces, can lead to increased respiratory strain and fatigue. The combustion of coal releases air pollutants, including fine particulate matter (PM2.5), sulfur dioxide (SO2), and nitrogen oxides (NOx), which are associated with cardiovascular and respiratory issues.[8,9] Workers may also experience heat stress due to high ambient temperatures, noise exposure that can impact cognitive performance, and potential exposure to chemical byproducts. Previous research has suggested a link between respiratory function and cognitive performance; individuals with impaired lung function may exhibit slower information processing speed and poorer performance in other cognitive tasks.[10–12] Studies have also shown that workers in other industries with similar physical demands and respiratory challenges, such as construction and mining, also show a decline in lung function and cognitive function.[13] Even within the general population, a correlation between reduced lung function and cognitive performance has been observed.[10] It's important to note that this relationship can be influenced by various confounding factors, including age, smoking status, pre-existing health conditions (eg, asthma, COPD), and socioeconomic factors that may affect both respiratory and cognitive health.[14]

Physical activity and sedentary behavior are recognized as important determinants of health outcomes, including cognitive function.[15] Although physical activity has consistently been associated with improved cognitive performance and a lower risk of cognitive decline, sedentary behavior is associated with poorer cognitive outcomes. However, the relationship between physical activity, sedentary behavior, and cognitive function in individuals engaged in physically demanding occupations, such as those in coal power plants, remains unclear. Some studies suggest that high levels of occupational physical activity may not offer the same protective effects on cognitive function and other health outcomes as leisure-time physical activity, possibly due to the cumulative effects of physical exertion and fatigue.[16,17] Similarly, the impact of sedentary behavior on cognitive function in this population may be influenced by the nature of their work and the limited opportunities for physical activity outside of work hours.[18,19] While studies, including randomized controlled trials, suggest that aerobic exercise and respiratory training can improve pulmonary function and potentially enhance certain cognitive functions such as abstraction and mental flexibility, especially in older adults,[20] there is still a gap in the research. Few studies have specifically examined the relationship between respiratory function and cognitive performance in both active and inactive workers with physically demanding occupations, considering both occupational and leisure-time physical activity.

This study investigated the association between respiratory muscle strength, measured by Maximal Inspiratory Pressure (MIP) and Peak Expiratory Flow (PEF), and information processing speed in active and inactive coal power plant workers. MIP reflects the strength of the diaphragm and other inspiratory muscles, while PEF indicates the strength of the expiratory muscles and the ability to expel air forcefully.[21] Impairments in MIP and PEF are indicative of reduced lung function and have been associated with increased morbidity and mortality.[22] We hypothesized that poorer respiratory function (lower MIP and PEF) could be associated with slower information processing speed in both active and inactive workers. Additionally, we explored the potential moderating effect of sedentary behavior on this association. Understanding these relationships has significant implications for occupational health policies and interventions aimed at mitigating workplace hazards and promoting worker well-being.

# Methods

## Participants

A total of 171 coal power plant workers were recruited for this study in cooperation with the Hadong Bitdream Headquarters in Gyeongsangnam-do, South Korea. Recruitment notices were posted with the assistance of Hadong Southern Power, and interested volunteers were invited to participate. The inclusion criteria were: (1) men and women currently employed at a coal power plant, and (2) individuals who voluntarily provided written informed consent after understanding the study's purpose. Exclusion criteria were: (1) difficulty in independent walking, (2) severe or unstable

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physical conditions that could interfere with study completion (eg, acute and severe asthma, severe or unstable cardiovascular disease, active peptic ulcer, severe liver disease, or kidney disease requiring dialysis), and (3) any other medical condition that could pose additional risk to the participant or confound the study results. The study protocol and procedures were approved by the Institutional Review Board (IRB) of Pusan National University Hospital (IRB number: 2301–015-122). All participants provided written informed consent prior to enrollment. All recruitment and consent interactions were conducted privately. Participants were assured that their decision to participate would not affect their employment status or job evaluation, and that all data provided to the research sponsor would be de-identified. Upon enrollment, participants first completed a questionnaire to gather basic demographic information and the International Physical Activity Questionnaire (IPAQ) to assess their physical activity levels. This was followed by a body composition analysis using the InBody S10 device. Subsequently, information processing speed was assessed using a tablet-based cognitive assessment tool developed by the National Center for Geriatrics and Gerontology (NCGG) in Japan. Finally, respiratory function assessments were conducted as the last step of the evaluation.

## Measurements

### Information Processing Speed

Information processing speed was assessed using a tablet-based cognitive assessment tool developed by the NCGG in Japan. This tool, implemented on an iPad (Apple, Cupertino, CA, USA), has demonstrated good reliability in previous research published by Makizako, Shimada, Park, Doi, Yoshida, Uemura, Tsutsumimoto and Suzuki.[23] The assessment, administered by trained professionals, utilized the Symbol Digit Substitution Task (SDST). The SDST is a widely used neuropsychological test for assessing processing speed, visual scanning, and working memory, and it has been extensively employed in research involving adult populations.[24] The professionals received comprehensive training on the assessment software, including interface navigation, participant interaction, and technical troubleshooting. Training sessions also emphasized consistent delivery of instructions and practice trials to ensure participants fully understood the task requirements and to minimize variability in test administration. During the SDST, nine pairs of numbers and symbols were displayed at the top of the iPad screen, with a target symbol presented in the center. Participants were instructed to select the number corresponding to the target symbol from the options at the bottom of the screen as quickly and accurately as possible. The software automatically recorded response times and accuracy. One point was awarded for each correct response within a 120-second time limit, and the total number of correct responses served as the primary measure of information processing speed. Higher scores indicate faster and more efficient information processing. To ensure consistency and minimize distractions, all assessments were conducted in a quiet, controlled environment. Participants were provided with clear instructions and completed practice trials to familiarize themselves with the iPad interface and task demands before beginning the formal assessment.

### Respiratory Function Assessment

Respiratory function was assessed using pulmonary function tests (PFT) and were conducted using desktop spirometer (Pony FX).[25] Prior to each testing session, the spirometer was calibrated using a 3-liter calibration syringe, following the manufacturer's guidelines to ensure measurement accuracy. Respiratory muscle strength was evaluated by measuring the MIP and PEF rates. The PFT was conducted using a computer-connected sterilized cylinder. Participants were instructed to inhale maximally and then exhale forcefully and completely through the cylinder. The test was repeated, and the best of three technically acceptable maneuvers was used for analysis. PEF was measured as the highest flow achieved from maximum forced expiration, starting from maximum lung inflation. To measure MIP, participants were asked to inhale as deeply and quickly as possible against a closed airway, starting from the residual volume. The highest values of three acceptable and reproducible maneuvers were recorded for each parameter. Participants with MIP or PEF values less than 80% of the predicted value were classified as having reduced respiratory muscle strength.[26]

### Moderate-to-Vigorous Physical Activity (MVPA) and Sedentary Behavior

Physical activity levels were assessed using the IPAQ.[27] Participants self-reported and self-administered their daily sedentary


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time and weekly MVPA duration. For analysis, participants were categorized into four groups based on different models: those reporting > 9 hours or < 9 hours of sedentary time daily[28] and ≥150 minutes or < 150 minutes of MVPA weekly.[29]

### Covariates

Demographic variables included age, sex (dichotomized as male/female), and education level (in years). Anthropometric measures included body mass index (BMI), skeletal muscle mass (SMM), and body fat percentage, all of which were measured using bioelectrical impedance analysis. Lifestyle factors included alcohol consumption (binary: yes/no) and smoking status (categorized as never, former, or current smoker). Marital status was included as a sociodemographic factor. Physical activity levels were assessed using the IPAQ, which provides data on total physical activity (measured in metabolic equivalents [MET] minutes per week) and sedentary behavior (measured in hours per day).

## Statistical Analyses

Data were analyzed using IBM SPSS Statistics (version 27.0; IBM Corp., Armonk, NY, USA). Descriptive statistics, including number and percentage (%) for categorical variables and mean and standard deviation (SD) for continuous variables, were reported for each group. Independent t-tests and chi-square tests were conducted to examine the differences between the active and inactive groups (those with and without prolonged sedentary behavior). Multiple linear regression analyses were performed to investigate the association between MIP and PEF and information processing speed. A priori power analysis using G*Power indicated that a sample size of approximately 123 was needed to detect a medium effect size ($f^2 = 0.15$) with 80% power and a significance level (α) of 0.05 in a multiple linear regression model with 11 predictors. Unstandardized coefficients (B) and their 95% confidence intervals (CI) were calculated. To control for potential confounding variables affecting these relationships, covariates, such as age, sex, BMI, and other relevant variables, were included in the models. Additionally, collinearity diagnostics were conducted to identify any potential multicollinearity issues among the predictor variables to ensure the stability and reliability of the models. Statistical significance was set at $p < 0.05$.

# Results

## Characteristics of Participants

Table 1 presents the characteristics of the 171 participants, including 136 men (79.5%), with an age range of 21–59 years. The characteristics of participants divided into active (n=97) and inactive (n=74) groups based on their physical activity levels are also presented in Table 1. The mean age was similar in both groups (active: 39.86 ± 10.82 years; inactive: 40.14 ± 10.72 years), and there was no significant difference in education years between the groups (active: 15.19 ± 1.56 years; inactive: 15.46 ± 1.26 years). The BMI was comparable between the groups, and no significant differences were observed in skeletal muscle mass (SMM) or fat percentage. As expected, the active group had significantly higher total IPAQ scores (3953.44 ± 2631.78 METs/week) compared to the inactive group (1421.90 ± 1165.88 METs/week; $p < 0.001$), whereas sedentary time was not significantly different between groups. No significant differences were observed in alcohol consumption, marital status, or smoking habits between the active and inactive groups.

The characteristics of the participants stratified into non-prolonged and prolonged sedentary groups are presented in Table 2. The participants were categorized into non-prolonged (n=121) and prolonged (n=50) sedentary groups based on their daily sedentary time. The prolonged sedentary group was significantly younger (36.04 ± 10.57 years) than the non-prolonged sedentary group (41.60 ± 10.43 years; $p = 0.002$). The prolonged sedentary group had a significantly higher proportion of women (38.0%) than the non-prolonged sedentary group (13.2%; $p = 0.001$), and a higher percentage of unmarried participants (56.0% vs 33.1%; $p = 0.009$).

## Associations of MIP or PEF on Information Processing Speed Test

Table 3 presents the associations between respiratory muscle strength (MIP and PEF) and information processing speed in the overall sample. After adjusting for covariates, no significant associations were found between MIP or PEF and information processing speed.

However, when stratified by physical activity levels (Table 4), interesting patterns emerged. In the active group (≥150 min/week of MVPA), individuals with MIP <80% revealed significantly lower information processing speed scores (B = −6.341, 95%

**Table 1** Characteristics of Coal Power Plant Workers Stratified by Physical Activity Level (Active Vs Inactive)

| Continuous Variables | Active Group (n=97) | Inactive Group (n=74) | p-value |
|---|---|---|---|
| Age, mean (SD); years | 39.86 (10.82) | 40.14 (10.72) | 0.867 |
| BMI, mean (SD); kg/m$^2$ | 24.40 (2.95) | 24.29 (3.29) | 0.822 |
| SMM, mean (SD); kg | 31.40 (5.11) | 30.32 (5.90) | 0.202 |
| Fat percentage, mean (SD); % | 22.32 (6.97) | 24.00 (6.10) | 0.101 |
| IPAQ Total, mean (SD); Mets/week | 3953.44 (2631.78) | 1421.90 (1165.88) | <0.001* |
| SB per day, mean (SD); min/day | 392.47 (200.20) | 420.54 (240.25) | 0.406 |
| Education years, mean (SD); years | 15.19 (1.56) | 15.46 (1.26) | 0.220 |
| **Categorical variables** | | | |
| Female (%) | 15 (15.5) | 20 (27.0) | 0.096 |
| Alcohol consumers (%) | | | 0.337 |
| Non-drinker | 21 (21.6) | 23 (31.1) | |
| Moderate drinker | 16 (16.5) | 9 (12.2) | |
| Excessive drinker | 60 (61.9) | 42 (56.8) | |
| Marital status, unmarried (%) | 40 (41.2) | 28 (37.8) | 0.770 |
| Smoking habitual (%) | | | 0.665 |
| Non-smoker | 63 (64.9) | 50 (67.6) | |
| Past smoker | 12 (12.4) | 6 (8.1) | |
| Current smoker | 22 (22.7) | 18 (24.3) | |

**Abbreviations**: SD, standard deviation; BMI, body mass index; SMM, skeletal muscle mass; SB, sedentary behavior; Mets, metabolic equivalents.; *p<0.05.

**Table 2** Characteristics of Coal Power Plant Workers Stratified by Sedentary Behavior (Non-Prolonged Vs Prolonged)

| Continuous variables | Non-prolonged Sedentary Group (n=121) | Prolonged Sedentary Group (n=50) | p-value |
|---|---|---|---|
| Age, mean (SD); years | 41.60 (10.43) | 36.04 (10.57) | 0.002* |
| BMI, mean (SD); kg/m$^2$ | 24.38 (3.09) | 24.27 (3.14) | 0.826 |
| SMM, mean (SD); kg | 31.47 (4.98) | 29.62 (6.40) | 0.045* |
| Fat percentage, mean (SD); % | 22.54 (6.50) | 24.27 (6.88) | 0.122 |
| IPAQ Total, mean (SD); Mets/week | 2967.30 (2604.34) | 2593.22 (2091.30) | 0.368 |
| SB per day, mean (SD); min/day | 293.64 (124.36) | 673.20 (152.63) | <0.001* |
| Education years, mean (SD); years | 15.29 (1.45) | 15.34 (1.44) | 0.835 |
| **Categorical variables** | | | |
| Female (%) | 16 (13.2) | 19 (38.0) | 0.001* |
| Alcohol consumers (%) | | | 0.404 |
| Non-drinker | 33 (27.3) | 11 (22.0) | |
| Moderate drinker | 15 (12.4) | 10 (20.0) | |
| Excessive drinker | 73 (60.3) | 29 (58.0) | |
| Marital status, unmarried (%) | 40 (33.1) | 28 (56.0) | 0.009* |
| Smoking habitual (%) | | | 0.192 |
| Non-smoker | 75 (62.0) | 38 (76.0) | |
| Past smoker | 15 (12.4) | 3 (6.0) | |
| Current smoker | 31 (25.6) | 9 (18.0) | |

**Abbreviations**: SD, standard deviation; BMI, body mass index; SMM, skeletal muscle mass; SB, sedentary behavior; Mets, metabolic equivalents; *p<0.05.


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**Table 3** Associations Between Respiratory Muscle Strength (MIP and PEF) and Information Processing Speed in Coal Power Plant Workers (n=171)

| | Information Processing Speed (score) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Crude model | | | | Adjusted model | | | |
| | B | 95% CI | *p* | $f^2$ | B | 95% CI | *p* | $f^2$ |
| MIP | | | | | | | | |
| ≥80% | ref | | | | Ref | | | |
| < 80% | 0.470 | (−5.348, 6.288) | 0.873 | | −3.654 | (−7.825, 0.518) | 0.169 | |
| PEF | | | | | | | | |
| ≥80% | ref | | | | ref | | | |
| < 80% | 6.762 | (0.377, 13.148) | 0.038* | | −3.480 | (−8.453, 1.493) | 0.086 | |

**Notes**: Adjusted model: sociodemographics (age, sex, education years, marital status) and health status (BMI, skeletal muscle mass, body fat percentage, alcohol consumption, smoking status, total physical activity per week, and sedentary behavior per day); *p<0.05.

**Table 4** Associations Between Respiratory Muscle Strength (MIP and PEF) and Information Processing Speed in Coal Power Plant Workers, Stratified by Physical Activity Level (Active Vs Inactive)

| | Information Processing Speed (score) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Crude model | | | Adjusted model | | | |
| | B | 95% CI | *p* | B | 95% CI | *p* | $f^2$ |
| Active group (≥150 min/ weeks of MVPA, n= 97) | | | | | | | |
| MIP | | | | | | | |
| ≥80% | ref | | | Ref | | | |
| < 80% | −5.684 | (−13.315, 1.947) | 0.142 | −6.341 | (−11.709, −0.972) | 0.021* | |
| PEF | | | | | | | |
| ≥80% | ref | | | ref | | | |
| < 80% | 0.371 | (−8.101, 8.842) | 0.931 | −8.383 | (−14.601, −2.165) | 0.009* | |
| | B | 95% CI | *p* | B | 95% CI | *p* | |
| Inactive group (<150 min/ weeks of MVPA, n= 74) | | | | | | | |
| MIP | | | | | | | |
| ≥80% | ref | | | Ref | | | |
| < 80% | 8.324 | (−0.591, 17.24) | 0.067 | −0.153 | (−7.520, 7.214) | 0.967 | |
| PEF | | | | | | | |
| ≥80% | ref | | | ref | | | |
| < 80% | 15.427 | (5.77, 25.084) | 0.002* | 5.573 | (−3.128, 14.274) | 0.205 | |

**Notes**: Adjusted model: sociodemographics (age, sex, education years, marital status) and health status (BMI, skeletal muscle mass, body fat percentage, alcohol consumption, smoking status, and sedentary behavior per day); *p<0.05.

**Table 5** Associations Between Respiratory Muscle Strength (MIP and PEF) and Information Processing Speed in Coal Power Plant Workers, Stratified by Sedentary Behavior (Prolonged Vs Non-Prolonged)

| | Information Processing Speed (score) | | | | | |
|---|---|---|---|---|---|---|
| | Crude model | | | Adjusted model | | |
| | B | 95% CI | *p* | B | 95% CI | *p* |
| Prolonged sedentary group (≥9 hours/ day, n= 50) | | | | | | |
| MIP | | | | | | |
| ≥80% | ref | | | Ref | | |
| < 80% | 9.396 | (−0.495, 19.287) | 0.062 | 5.836 | (−1.477, 13.15) | 0.114 |
| PEF | | | | | | |
| ≥80% | ref | | | ref | | |
| < 80% | 10.911 | (1.152, 20.671) | 0.029* | 2.435 | (−5.876, 10.745) | 0.556 |
| | B | 95% CI | *p* | B | 95% CI | *p* |
| Non-prolonged sedentary group (< 9 hours/ day, n= 121) | | | | | | |
| MIP | | | | | | |
| ≥80% | ref | | | ref | | |
| < 80% | −4.166 | (−10.937, 2.605) | 0.226 | −6.655 | (−11.684, −1.626) | 0.010* |
| PEF | | | | | | |
| ≥80% | ref | | | ref | | |
| < 80% | 1.830 | (−6.275, 9.934) | 0.656 | −6.258 | (−12.881, 0.366) | 0.064 |

**Notes**: Adjusted model: sociodemographics (age, sex, education years, marital status) and health status (BMI, skeletal muscle mass, body fat percentage, alcohol consumption, smoking status, and total physical activity per week); *p<0.05.

CI: −11.709 to −0.972, p = 0.021) than those with MIP ≥80%. Similarly, in the active group, those with PEF <80% demonstrated significantly lower information processing speed scores (B = −8.383, 95% CI: −14.601 to −2.165, p = 0.009) than those with PEF ≥80%. Notably, no significant associations were observed with either MIP or PEF values in the inactive group.

Further stratification by sedentary behavior revealed a significant association in the non-prolonged sedentary group (Table 5). In the non-prolonged sedentary group (<9 hours/day), participants with MIP <80% exhibited significantly lower information processing speed scores (B = −6.655, 95% CI: −11.684 to −1.626, p = 0.010) than those with MIP ≥80%. No significant associations were observed in the prolonged sedentary group. These findings suggest that the relationship between respiratory muscle strength and information processing speed is moderated by both physical activity levels and sedentary behavioral patterns.

## Discussion

This study examined the association between respiratory muscle strength and information processing speed in a unique population of 171 coal power plant workers. In the active group (≥150 min/week of MVPA), individuals with lower MIP or PEF (<80%) values revealed significantly lower information processing speed scores than their counterparts with higher respiratory muscle strength. Similarly, in the non-prolonged sedentary group (<9 h/day), participants with a lower MIP exhibited significantly lower cognitive performance.

To our knowledge, this is the first study to examine the association between respiratory function and cognitive performance in coal power plant workers. These findings challenge the conventional assumption that meeting physical activity guidelines or avoiding prolonged sedentary behavior is universally protective.[30] This finding suggests that the relationship between respiratory muscle strength and cognitive function may be more nuanced in this occupational setting. For workers who do not meet physical activity recommendations or engage in prolonged sedentary behavior, other factors may play a dominant role in cognitive performance. In coal power plant workers who adhere to recommended physical activity guidelines, maintaining adequate respiratory muscle strength might be particularly crucial for preserving cognitive function.[31,32]

These results have important implications for occupational health strategies for coal-fired power plants. Although promoting physical activity and reducing sedentary time remain crucial, our findings indicate that monitoring respiratory muscle function may be essential for workers who are already physically active or maintain a lower sedentary time. This group, which is typically considered to be at lower risk, may require targeted interventions to maintain both respiratory and cognitive health. The observed associations could be related to the specific occupational demands of coal power plant workers. Those in more physically active roles or those with less sedentary time may be exposed to different occupational hazards or engage in tasks that place unique demands on their respiratory system and cognitive functions.[33,34] For instance, these workers may have increased exposure to coal dust and other particulate matter, which, over time, can affect their respiratory function.[7,35] They may also work near high-temperature equipment, leading to thermal stress, which can affect both physical and cognitive performance.[36] Constant exposure to high noise levels from machinery and potential chemical exposures (such as sulfur dioxide, nitrogen oxides, and heavy metals) can have detrimental effects on both respiratory and neurological functions.[37–39] Moreover, these workers are typically engaging in physically demanding tasks, such as lifting heavy equipment or performing repetitive actions, which can lead to fatigue and potentially influence both respiratory and cognitive functions.[40,41] Furthermore, they may work in confined spaces with limited air circulation, further challenging their respiratory system.[42] Their roles may expose them to higher levels of vibration from equipment and electromagnetic fields from power generation machinery, both of which could impact their overall health and cognitive function.[43] Additionally, workers with more active roles may be required to make quick and critical decisions, placing unique demands on their cognitive functions.[18]

These occupational hazards and demands could potentially explain the observed association between respiratory muscle strength and cognitive function in more active and less sedentary workers. The cumulative effect of these exposures and demands might manifest more clearly in workers who otherwise follow health recommendations for physical activity, highlighting the complex interplay between occupational exposures, lifestyle factors, and health outcomes in this unique workforce. Further research is required to explore workplace-specific factors, and to develop targeted interventions to improve workers' respiratory and cognitive health. For active workers in coal-fired power plants, interventions might focus on mitigating exposure to respiratory hazards through improved ventilation, personal protective equipment, and engineering controls. For example, implementing stricter dust control measures or providing respirators with higher protection factors could reduce particulate inhalation. Future research should focus on evaluating the effectiveness and feasibility of such interventions in this specific occupational setting, taking into account the unique challenges and opportunities presented.

Our study has several limitations. First, the cross-sectional design prevents us from establishing causality between respiratory function, physical activity, sedentary behavior, and information processing speed. Future longitudinal studies are needed to explore these relationships over time. Second, the sample, consisting solely of coal power plant workers, limits the generalizability of the findings. Comparisons with other occupational groups are needed to determine the uniqueness of these associations. Third, the IPAQ used does not distinguish between occupational and leisure-time physical activity, making it difficult to attribute observed associations to a specific type of activity. Fourth, voluntary participation may have introduced selection bias, as our sample may not fully represent the coal power plant workforce. For example, workers with pre-existing health concerns might be underrepresented. Finally, unmeasured factors such as history of respiratory diseases, socioeconomic status, diet, and sleep quality could have confounded our results. Future research should employ longitudinal designs, utilize measures that differentiate between occupational and leisure-time physical activity, and control for a broader range of potential confounders. Intervention studies are also needed to test whether improving respiratory function or modifying activity patterns can enhance cognitive function in this population.

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## Conclusion

This study provides insights into the relationships among occupational physical activity, sedentary behavior, respiratory muscle strength, and cognitive function in coal power plant workers. Our findings highlight the potential importance of considering occupational factors, particularly respiratory hazards and the unique physical demands of this work environment, when designing health interventions. Future research should employ longitudinal designs to establish temporal relationships, utilize more precise measures of physical activity, and consider a broader range of potential confounders. Furthermore, research should focus on developing and evaluating targeted interventions, such as those aimed at mitigating exposure to respiratory hazards and promoting appropriate physical activity. These interventions should consider the unique challenges and opportunities presented by the coal power plant work environment, with the ultimate goal of improving the overall health and well-being of this workforce.

## Ethics Approval and Consent to Participate

Each participant provided written informed consent before the start of the study. The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Pusan National University Hospital (IRB number: 2301-015-122).

## Data Sharing Statement

The data used in this study were obtained from the corresponding author upon request.

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## Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Disclosure

The authors declare no competing interests in this work.

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