

# Obstructive Sleep Apnea Hypopnea Syndrome: A Comparative Study of Cardiopulmonary Exercise Testing Outcomes

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**Abstract:** Obstructive sleep apnea hypopnea syndrome (OSAHS) is a condition characterized by recurrent episodes of respiratory arrest or hypoventilation during sleep, leading to airflow limitation lasting 10 seconds or more<sup>[1]</sup>. Clinically, it manifests as snoring, intermittent respiratory arrest, frequent nocturnal awakenings, increased nighttime urination, poor sleep quality, daytime somnolence, and cognitive decline. Diagnosis relies on polysomnography (PSG), which monitors brain waves, eye movements, and chin muscle tone to assess sleep-wake states, as well as thoracoabdominal movements, oronasal airflow, and blood oxygen saturation to identify apneas and hypopneas. Cardiopulmonary exercise testing (CPET) is an objective, non-invasive method for evaluating cardiopulmonary reserve and exercise tolerance, distinct from conventional electrocardiogram-based exercise tests and static pulmonary function tests<sup>[2]</sup>. This study aims to explore the cardiopulmonary functional changes in OSAHS patients and the clinical application value of CPET by comparing CPET results between OSAHS patients and healthy adults.

## 1. Materials and Methods

### 1.1 General Information

A retrospective selection was made of OSAHS patients who underwent cardiopulmonary exercise testing at the Department of Otorhinolaryngology Head and Neck Surgery, the First Affiliated Hospital of Anhui Medical University, from December 2020 to January 2024, as the experimental group. Healthy individuals from the Department of Rehabilitation Medicine of the same hospital, who also participated in cardiopulmonary exercise testing, were chosen as the control group. Inclusion criteria for the experimental group were: ① Diagnosis of OSAHS<sup>[3]</sup> confirmed by PSG at our hospital's Department of Otorhinolaryngology Head and Neck Surgery; ② Age between 18 and 60 years; ③ No prior OSAHS surgery. Exclusion criteria included: ① Presence of other cardiopulmonary diseases, such as COPD, asthma, coronary heart disease, heart failure, etc.; ② Presence of mental or cognitive disorders, or inability to complete CPET testing for other reasons; ③ Excessive missing retrospective data. The control group

consisted of healthy individuals, typically school and community volunteers, without OSAHS or other cardiopulmonary diseases. Based on these criteria, 36 eligible OSAHS patients were identified, with 3 cases excluded due to significantly abnormal data, resulting in a final experimental group of 33 and a control group of 17. The general information of the two groups is shown in **Table-1**, with no statistically significant differences in age, gender ratio, height, or weight ( $P < 0.05$ ).

**Table-1.** General Information of the Two Groups

| Group              | Age(years)  | Gender (Male/Female) | Height (cm) | Weight (kg) |
|--------------------|-------------|----------------------|-------------|-------------|
| Experimental Group | 39.82±10.12 | 27/6                 | 169.67±7.62 | 84.83±15.51 |
| Control Group      | 34.88±9.59  | 14/3                 | 172.00±6.94 | 78.94±14.56 |
| Statistical Value  | 1.94        | 0.002                | -1.08       | -1.05       |
| P-value            | 0.057       | 0.989                | 0.296       | 0.513       |

## 1.2 Experimental Methods

Prior to the test, all OSAHS patients and healthy individuals participating in the exercise test were fully informed about the entire exercise test process and potential risks, and they voluntarily signed the “Informed Consent for Cardiopulmonary Exercise Testing.” Height, weight, age, and contact information were recorded. Test subjects were instructed not to be fasting or overly full, to bring drinking water, wear loose clothing, and ensure the test environment was maintained at a temperature between 20 to 25°C. The testing equipment used was a cardiopulmonary exercise testing system (Nanjing Hanya, Smax58ce Exercise Cardiopulmonary Function Testing System). The test included both static pulmonary function testing and exercise cardiopulmonary testing.

### 1.2.1 Static Pulmonary Function Testing

Static pulmonary function testing was conducted while the subjects were in a state of calm. After calibrating the flow sensor and gas analyzer, the following parameters were tested: vital capacity parameters (including VC, VC%pred, etc.), forced vital capacity parameters (FVC, FEV1, FEV1/FVC, FEV1%pred, PEF, etc.), and maximum voluntary ventilation (MVV). A 2-minute rest was taken after completing the test.

### 1.2.2 Exercise Cardiopulmonary Testing

After the subjects were fitted with all sensors and seated on the cycle ergometer, the height of the ergometer was adjusted according to the subject's height. A breathing mask was worn, and based on the individual's condition, an incremental load (10-25W/min) was selected on the instrument interface for an 8-12 minute exercise test. The exercise used the original equipment plug-in of the cardiopulmonary exercise testing system, dynamically monitoring the subject's

12-lead electrocardiogram, blood pressure, heart rate, pulse oximetry, and recording O<sub>2</sub> and CO<sub>2</sub> gas exchange data using real-time respiration. Except for blood pressure, which was recorded once per minute, all other indicators were recorded in real-time. The entire exercise cardiopulmonary test included four stages: rest, warm-up, exercise, and recovery. During cycling, the rotation speed was maintained between 50-60r/min. Physicians encouraged subjects to exert maximum effort until exhaustion, while closely monitoring their responses. If the subject could not continue or met the criteria for terminating the exercise test, they immediately entered the recovery phase. After the test, the following indicators were recorded: peak oxygen uptake (VO<sub>2</sub>peak/kg), percentage of predicted peak oxygen uptake (VO<sub>2</sub>peak%pred), anaerobic threshold oxygen uptake (VO<sub>2</sub>@AT), peak oxygen pulse (peak O<sub>2</sub> PULSE), and percentage of predicted peak oxygen pulse (peak O<sub>2</sub> PULSE%pred).

### 1.3 Statistical Methods

Statistical analysis was performed using SPSS 26.0 software. Count data were expressed as proportions and analyzed using the chi-square test. Measurement data were expressed as mean  $\pm$  standard deviation ( $\bar{x} \pm s$ ) and analyzed using the t-test between the two groups. A P-value  $< 0.05$  was considered statistically significant.

## 2. Results

In the comparison of static pulmonary function between the two groups, statistically significant differences were found in vital capacity (VC), inspiratory capacity predicted value (IC%pred), expiratory reserve volume (ERV), forced expiratory volume in one second predicted value (FEV1%pred), maximum voluntary ventilation (MVV), and maximum voluntary ventilation predicted value (MVV%pred) ( $P < 0.05$ ) (**Table-2**). No significant differences were found in the other parameters ( $P > 0.05$ ). In exercise cardiopulmonary testing, only peak oxygen uptake (VO<sub>2</sub>peak/kg) and peak metabolic equivalents (Peak Mets) showed statistically significant differences ( $P < 0.05$ ), while anaerobic threshold oxygen uptake (VO<sub>2</sub>@AT), peak oxygen pulse (peak O<sub>2</sub> PULSE), and peak oxygen uptake (VO<sub>2</sub>peak) did not show significant differences ( $P > 0.05$ ) (**Table-3**).

**Table-2.** Comparison of Static Pulmonary Function Between the Two Groups

| Item    | Experimental Group | Control Group     | t-value | P-value |
|---------|--------------------|-------------------|---------|---------|
| VC      | 3.83 $\pm$ 0.92    | 4.31 $\pm$ 1.02   | -1.68   | 0.099   |
| VC%pred | 85.24 $\pm$ 12.04  | 95.12 $\pm$ 13.96 | -2.60   | 0.012   |
| IC      | 2.46 $\pm$ 0.57    | 2.60 $\pm$ 0.56   | -0.82   | 0.414   |
| IC%pred | 76.03 $\pm$ 11.58  | 84.53 $\pm$ 14.56 | -2.25   | 0.029   |
| ERV     | 1.37 $\pm$ 0.57    | 1.85 $\pm$ 0.85   | -2.38   | 0.021   |

|               |              |              |        |       |
|---------------|--------------|--------------|--------|-------|
| FVC           | 3.93±0.92    | 4.31±1.00    | -1.36  | 0.180 |
| FVC%pred      | 88.82±11.49  | 91.04±26.63  | -0.413 | 0.681 |
| FEV1          | 2.93±0.72    | 3.38±0.90    | -1.92  | 0.060 |
| FEV1%pred     | 80.82±11.56  | 89.47±16.46  | -2.16  | 0.035 |
| FEV1/FVC      | 74.63±5.63   | 74.83±15.46  | -0.06  | 0.948 |
| FEV1/FVC%pred | 92.42±6.91   | 93.53±8.35   | -0.49  | 0.620 |
| PEF           | 5.56±1.83    | 6.20±2.41    | -1.05  | 0.297 |
| MVV           | 113.28±34.32 | 135.20±37.33 | -2.07  | 0.043 |
| MVV%pred      | 80.18±20.37  | 95.53±19.09  | -2.57  | 0.013 |

Note: VC: Vital Capacity, %pred: Percentage of Predicted Value, IC: Inspiratory Capacity, ERV: Expiratory Reserve Volume, FVC: Forced Vital Capacity, FEV1: Forced Expiratory Volume in One Second, FEV1/FVC: Ratio of FEV1 to FVC, PEF: Peak Expiratory Flow, MVV: Maximum Voluntary Ventilation.

**Table-3.** Comparison of Exercise Cardiopulmonary Function Between the Two Groups

| Item          | Experimental Group | Control Group  | t-value | P-value |
|---------------|--------------------|----------------|---------|---------|
| VO2peak       | 1742.82±403.96     | 1770.12±426.13 | -0.222  | 0.825   |
| VO2peak%pred  | 67.88±11.25        | 64.58±12.42    | -0.946  | 0.349   |
| VO2peak/kg    | 20.79±4.18         | 24.28±6.01     | -2.40   | 0.020   |
| VO2@AT(ml/kg) | 1214.06±298.90     | 1213.35±345.61 | 0.008   | 0.994   |
| Peak Mets     | 5.94±1.20          | 7.56±2.70      | -2.93   | 0.005   |
| peak O2 PULSE | 12.00±2.47         | 11.08±2.74     | 1.197   | 0.237   |

Note: VO2peak: Peak Oxygen Uptake, %pred: Percentage of Predicted Value, VO2peak/kg: Peak Oxygen Uptake per Kilogram of Body Weight, VO2@AT: Oxygen Uptake at Anaerobic Threshold, Peak Mets: Peak Metabolic Equivalents, peak O2 PULSE: Peak Oxygen Pulse.

### 3. Discussion

Obstructive sleep apnea hypopnea syndrome (OSAHS) is a disorder that severely affects patients' quality of life and is associated with the development of various diseases, particularly cardiovascular, endocrine, respiratory, and neurological disorders. The results of this study indicate that in static pulmonary function testing, OSAHS patients showed significant decreases in vital capacity (VC), inspiratory capacity predicted value (IC%pred), expiratory reserve volume (ERV), forced expiratory volume in one second predicted value (FEV1%pred), maximum voluntary ventilation (MVV), and maximum voluntary ventilation predicted value (MVV%pred) compared to healthy individuals ( $P < 0.05$ ). Although these indicators are still within the normal range, the downward trend suggests that the ventilatory function of the lungs in OSAHS patients has been affected to some

extent. Vital capacity (VC) is an important indicator of lung ventilatory function, and its decline may be related to the repeated episodes of respiratory arrest and hypoventilation in OSAHS patients during the night, leading to insufficient ventilation in the lungs and consequently affecting pulmonary gas exchange. The decline in inspiratory capacity (IC) and expiratory reserve volume (ERV) may be related to impaired respiratory muscle function, especially as these muscles may suffer functional disorders due to chronic hypoxia during repeated episodes of respiratory arrest at night [4,5]. Additionally, the decrease in FEV1%pred and MVV further suggests that the patency of the airways in OSAHS patients may be compromised, which is associated with the common upper airway narrowing or collapse in OSAHS patients [6]. In exercise cardiopulmonary testing, the peak oxygen uptake ( $VO_{2peak}/kg$ ) and peak metabolic equivalents (Peak Mets) of OSAHS patients were significantly lower than those of healthy individuals ( $P < 0.05$ ). Peak oxygen uptake ( $VO_{2peak}/kg$ ) is an important indicator of cardiopulmonary function during exercise, and its decline indicates a reduced cardiopulmonary reserve capacity in OSAHS patients, which fails to meet the oxygen demands of exercise [7]. This may be related to the repeated episodes of nocturnal hypoxia in OSAHS patients, leading to a decline in the adaptive capacity of the heart and lungs. Moreover, the decrease in peak metabolic equivalents (Peak Mets) also suggests a reduction in exercise endurance in OSAHS patients, which may be related to insufficient cardiopulmonary function and abnormal muscle metabolism. Although no significant difference was found in anaerobic threshold oxygen uptake ( $VO_{2@AT}$ ), the close numerical values suggest that the oxygen utilization efficiency of OSAHS patients may not be significantly impaired during the initial stages of exercise, but the insufficiency of cardiopulmonary function becomes increasingly apparent during high-intensity exercise.

The possible reasons for the above results are that the repeated episodes of respiratory arrest and hypoventilation in OSAHS patients during the night lead to intermittent hypoxia and disruption of sleep structure, thereby triggering a series of pathological and physiological changes. Intermittent hypoxia can activate the sympathetic nervous system, resulting in elevated blood pressure and increased heart rate. Long-term effects can lead to cardiovascular remodeling and increased risk of cardiovascular diseases. Additionally, repeated sleep arousals and respiratory arrest events can also cause ventilatory dysfunction in the lungs, affecting pulmonary gas exchange and consequently impacting systemic oxygen supply [8,9]. The decline in static pulmonary function and exercise cardiopulmonary function in OSAHS patients in this study further confirms the negative impact of OSAHS on cardiopulmonary function.

CPET is clinically used for differential diagnosis and assessment of the degree of dyspnea and exercise limitation, preoperative risk assessment, and evaluation of the severity and prognosis of chronic obstructive pulmonary disease. In cardiovascular diseases, compared with left ventricular ejection fraction, New York Heart Association (NYHA) classification, and serum biomarkers, it

has significant application value in the grading of heart disease severity, selection of heart transplant indications, and prognosis of heart disease. There are currently few studies on CPET in OSAHS[9-11]. Although CPET cannot replace the diagnostic role of polysomnography, it has special significance in assessing the impact of OSAHS on patients' cardiopulmonary function. At present, in addition to surgery and non-invasive ventilator treatment for OSAHS, regular exercise also plays an important role, especially since many OSAHS patients also have obesity, hypertension, diabetes, and other problems. CPET can help physicians or therapists develop scientific exercise prescriptions to improve cardiopulmonary function and play an important role in weight reduction. Therefore, the clinical application value of CPET in OSAHS patients should be given due attention.

Although this study has revealed the changes in cardiopulmonary function in OSAHS patients, there are still some limitations. First, the sample size is small, and no stratified analysis was performed based on the severity of OSAHS, which may affect the accuracy and generalizability of the results. Second, the exercise habits and lifestyle of the patients were not assessed in detail, which may also affect cardiopulmonary function. Future research can further expand the sample size, perform stratified analysis on patients with different severities of OSAHS, and combine the exercise habits and lifestyle of patients to more comprehensively assess the impact of OSAHS on cardiopulmonary function. Additionally, long-term follow-up studies can be conducted to explore the dynamic changes of CPET in the treatment process of OSAHS patients, providing stronger support for clinical treatment.

In summary, this study compared the cardiopulmonary function indicators of OSAHS patients and healthy individuals through cardiopulmonary exercise testing (CPET) and found that the cardiovascular and pulmonary function levels of OSAHS patients are significantly lower than those of healthy individuals to a certain extent. The clinical application value of CPET in OSAHS patients should be given due attention, as it not only helps assess the impact of OSAHS on patients' cardiopulmonary function but also provides a basis for developing scientific exercise prescriptions.

## References

- [1] Luong S, Lezama L, Khan S. Diagnosis and Management of Obstructive Sleep Apnea: Updates and Review [J]. *Journal of Otorhinolaryngology, Hearing and Balance Medicine*, 2024, 5 (2): 16-16.
- [2] Otto M J, Levett H Z D, Grocott W P M. Cardiopulmonary Exercise Testing for Preoperative Evaluation: What Does the Future Hold? [J]. *Current Anesthesiology Reports*, 2020, 10 (1): 1-11.
- [3] Chinese Medical Association Sleep Medicine Professional Committee, Chinese Medical Association Neurology Branch Sleep Group. Chinese Guidelines for the Diagnosis and Treatment of Insomnia Comorbid with Obstructive Sleep Apnea in Adults (2024 Edition) [J]. *Chinese General Practice*, 2025, 28 (11): 1289-1303.
- [4] Zhang Chunyuan, Song Yuanlin, Hu Zhiyan, et al. Advances in the Determination Methods and Clinical Significance of Pulmonary Function Residual Volume [J]. *Biomedical Engineering and Clinical Medicine*, 2019, 23 (04): 487-492. DOI:10.13339/j.cnki.sglc.20190708.023.

- [5] Li Yun, Gao Yi, Zheng Jinping. Interpretation of the “2021 ERS/ATS Guidelines for the Interpretation of Routine Pulmonary Function Tests” [J]. Chinese Evidence-based Medical Journal, 2022, 22 (12): 1375-1381.
- [6] Meng Shan, Ye Sheng, Yang Jin, et al. Advances in the Application of Pulmonary Function Tests in the Diagnosis of Chronic Obstructive Pulmonary Disease [J]. Shandong Medical Journal, 2023, 63 (34): 111-115.
- [7] Shen Yihua, Lin Qin, Xie Liandi. Indicators and Interpretation of Cardiopulmonary Exercise Testing [J]. Chinese Journal of Hypertension, 2019, 27 (01): 84-88. DOI:10.16439/j.cnki.1673-7245.2019.01.025.
- [8] Wu Yifan, Xu Minghua, Du Liu, et al. Characteristics and Influencing Factors of Cardiopulmonary Function in Patients with Obstructive Sleep Apnea Hypopnea Syndrome Combined with Cardiovascular Disease [J]. Chinese Circulation Journal, 2024, 39 (11): 1078-1085.
- [9] Fishman A, Martinez F, Naunheim K, et al. National Emphysema Treatment Trial Research Group. A randomized trial comparing lung-volume-reduction surgery with medical therapy for severe emphysema [J]. N Eng J Med, 2003, 348:2059-2073.
- [10] Stevenson LW. Role of exercise testing in the evaluation of candidates for cardiac transplantation. In Wasserman K, ed. Exercise gas exchange in heart failure disease. Armonk, NY: Futura Publishing, 1996:271-286.
- [11] Chua TP, Ponikowski P, Harrington D, et al. Clinical correlates and prognostic significance of the ventilatory response to exercise in chronic heart failure [J]. J Am Col