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Original Article

Efficacy of cardiopulmonary rehabilitation nursing in enhancing pulmonary function, sleep quality, and living ability in COVID-19 patients

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Abstract: Objective: The purpose of this study was to elucidate the impact of cardiopulmonary rehabilitation nursing on the pulmonary function, sleep quality, and living ability of patients afflicted with Coronavirus Disease 2019 (COVID-19). Methods: A total of 98 patients with COVID-19 treated at The People's Hospital of Guang'an between September 2021 and January 2023 were retrospectively collected as the research subjects. Among them, 48 patients who received standard nursing care from September 2021 to September 2022 were set as the control group, and 50 patients who underwent cardiopulmonary rehabilitation nursing from October 2022 to January 2023 were set as the research group. The pulmonary function indicators [including Forced Expiratory Volume in 1 second (FEV1) and Left Ventricular Ejection Fraction (LVEF)], sleep quality [evaluated using the Pittsburgh Sleep Quality Index (PSQI)], and living ability [assessed by the 36-Item Short Form Survey (SF-36) scale] pre- and post-intervention were compared between the two groups. Results: Pre-intervention, FEV1, LVEF, PSQI scores, inflammatory factor levels [C-reactive protein (CRP), procalcitonin (PCT)], and SF-36 scores showed no significant differences between the two groups ($P>0.05$). Post-intervention, the research group exhibited notably enhanced FEV1 and LVEF, lower PSQI scores, lower CRP and PCT, and higher SF-36 scores compared with the control group, with statistical significance ($P<0.05$). Multifactorial logistic regression analysis showed that non-receipt of cardiopulmonary rehabilitation, age ≥60 years, concurrent respiratory failure, coexistent heart failure, and acid-base imbalance were independent risk factors of adverse outcomes in COVID-19 patients ($P<0.05$). Conclusion: Application of cardiopulmonary rehabilitation nursing in COVID-19 patients can significantly improve pulmonary function, sleep quality, and overall quality of life, and relieve the inflammatory state of the patients, thereby enhancing prognosis. This approach has certain value of popularization and application.

Keywords: Cardiopulmonary rehabilitation nursing, COVID-19, pulmonary function, sleep quality, quality of life

Introduction

According to the World Health Organization, approximately a quarter of deaths in middle-income countries worldwide are attributable to infectious diseases, malnutrition, and maternal health complications [1]. In the past 30 years, a variety of new infectious diseases have emerged in the world, such as avian influenza, Influenza A (H1N1), and novel coronavirus pneumonia (NCP), which have profoundly impacted global public health and economic stability [2, 3]. Epidemiological studies have pointed out that some emerging infectious diseases are characterized by rapid onset, swift transmission, extensive spread, and notable pathogen variability, and are prone to cause large-scale epidemics, among which NCP is one of the typical representatives [4, 5]. NCP, caused by the 2019 novel coronavirus (2019-nCoV), is characterized by its high transmissibility, insidious onset, high mortality rate, and prolonged incubation period. In severe cases, patients may rapidly progress to acute pneumonia and multi-organ failure, potentially resulting in mortality [6, 7]. According to the statistics of

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the World Health Organization, as of March 2022, 77 countries have reported a cumulative total of 480 million NCP cases, resulting in over 6 million deaths; there have been more than 450,000 diagnosed cases and over 13,000 fatalities in China [8, 9].

Clinical practice suggests that novel coronaviruses predominantly target the respiratory system, especially the lungs, while also affecting other organs such as the heart, gastrointestinal tract, and lymphoid tissues. Consequently, infected patients typically exhibit typical symptoms of pneumonia, such as respiratory distress and cough [10]. Due to the lack of relevant diagnostic and therapeutic experience, the nursing of Coronavirus Disease 2019 (COVID-19) patients in the past mostly referred to traditional pneumonia nursing approaches, resulting in a deficiency of targeted interventions [11]. Cardiopulmonary Rehabilitation Nursing Specialty Committee of Chinese Society of Rehabilitation Medicine has been established since June 2021. This committee is dedicated to improving the capacity of rehabilitation services, with a focus on maximizing the role of cardiopulmonary rehabilitation nursing in the prevention and management of cardiopulmonary chronic diseases. This study, through a retrospective analysis, discerned the affirmative value of incorporating cardiopulmonary rehabilitation nursing models into the management of COVID-19 patients. This application proved beneficial in enhancing pulmonary function, sleep quality, and overall quality of life for the afflicted individuals. This study innovatively applied a cardiopulmonary rehabilitation nursing model to patients with COVID-19, providing a novel approach to expedite the recovery process and offer novel insights into improving the prognosis of COVID-19 patients.

Materials and methods

Study population and grouping

A total of 98 patients with COVID-19 treated at The People's Hospital of Guang'an from September 2021 to January 2023 were retrospectively collected as the research subjects. Among them, 48 patients who received standard care from September 2021 to September 2022 were set as the control group, and 50 patients who underwent cardiopulmonary rehabilitation nursing from October 2022 to January 2023 were set as the research group. The control group included 26 males and 22 females, with an average age of 55.98±11.98 years, while the research group comprised 32 males and 18 females, with an average age of 56.32±12.56 years. The research protocol received ethical approval from the Ethics Committee of The People's Hospital of Guang'an, and data were sourced from the hospital's information system.

Inclusion and exclusion criteria for patients

Inclusion Criteria: (1) Patients diagnosed with novel coronavirus infection via pathogenetic testing [12] and treated in our hospital. (2) Patients with complete data in the hospital's patient information system, suitable for supporting this research.

Exclusion Criteria: (1) Patients with incomplete clinical data. (2) Patients with concurrent psychiatric disorders. (3) Patients with a history of sleep disorders. (4) Patients unable to perform self-care activities. (5) Patients with severe cases of NCP. (6) Patients who succumbed to the disease.

Intervention protocols

Patients in the control group received routine novel coronavirus nursing as follows: (1) Chest Pain Management: For patients' complaint of chest pain, the patients were guided to take a lateral position, encourage deep breathing and coughing to alleviate discomfort. Distraction methods were utilized for pain relief. In cases of acute pain, analgesic medications were used as per medical guidance. (2) Cough and Sputum Expectoration: Patients were guided in deep breathing exercises, coupled with tapping the chest to facilitate sputum expectoration. Increased fluid intake or expectorant medication was advised for patients with thick sputum.

Patients in the research group were given cardiopulmonary rehabilitation nursing on the basis of the control group. The specific measures are as follows: (a) Vital Signs and Respiratory Monitoring: Continuous monitoring of body temperature, respiratory rhythm, and oxygen saturation was conducted. Patients exhibiting hyperthermia were provided with antipyretic treatment, while those with lowered oxygen saturation received non-invasive respi-

ratory support, maintaining the patient's arterial oxygen concentration at about 98%. (b) Psychological Interventions: The cognitive, emotional, and behavioral states of patients were actively monitored. Supportive measures were taken to reinforce their treatment confidence and dispel anxiety and uncertainty through the provision of information. During intervention, the psychologists assessed the patient's anxiety and depression using the Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS), respectively, enabling the patient's ASRS and DSRS scores to maintain below 59 and 62, respectively. (c) Cardiopulmonary Rehabilitation Exercises: A regimen of rehabilitation exercises was conducted according to the specific condition of each patient, including activities such as walking, jogging, bridge poses, stretching sit-ups, and cross-body crunch, with the goal of restoring respiratory function. Patients were also instructed in respiratory training techniques such as pursed-lip breathing, abdominal breathing, and diaphragmatic breathing, to be performed 2-3 times daily with 5-8 repetitions each, based on patient tolerance. (d) Sleep Quality Interventions: To address sleep disturbances, staff actively worked to create a tranquil sleep environment, maintaining ward noise range of around 30-40 decibels. When needed, light music or sleep aids were utilized to improve sleep quality, striving to ensure approximately 8 h of sleep daily. Assessment points for both groups included pre-intervention (at hospital admission) and post-intervention (at hospital discharge).

Observation indices and evaluation criteria

This segment details the indicators and standards employed for evaluating the outcomes of the interventions, ensuring terminological consistency and academic rigor for journal publication.

Lung Function Assessment: To ascertain variations in lung function [Forced Expiratory Volume in 1 second (FEV1), Left Ventricular Ejection Fraction (LVEF)] pre- and post-intervention, patient evaluations were conducted using the pulmonary function testing instrument (Spiro-USB, SensorMedics), which facilitated precise measurement of key pulmonary indices.

Sleep Quality Analysis: The Pittsburgh Sleep Quality Index (PSQI) [13] was utilized to assess sleep quality differences between the two groups. The PSQI includes seven domains, including latency to sleep onset and overall sleep quality. Each domain is scored on a scale of 1-3 points, with the total score ranging from 7-21. Higher scores indicate poorer sleep quality among the subjects.

Inflammatory Factor Levels: The pre- and post-intervention serum levels of C-reactive protein (CRP) and procalcitonin (PCT) were compared between the two groups.

Quality of Life Evaluation: The 36-Item Short Form Survey (SF-36) Scale [14], including dimensions such as Physical Functioning (PF), Role Physical (RP), Bodily Pain (BP), General Health (GH), Vitality (VT), Social Functioning (SF), Role Emotional (RE), and Mental Health (MH), was employed to assess the quality of life. The total score of Physical Component Summary (PCS) was calculated by PF+RP+BP+GH, and the total score of Mental Component Summary (MCS) was calculated by VT+SF+RE+MH. Higher scores in these dimensions signify a better quality of life.

Prognostic Factor Analysis: The prognosis of patients was evaluated based on the disappearance of clinical symptoms post-intervention and three consecutive negative nucleic acid tests, indicative of a positive prognosis. Other outcomes were categorized as negative prognoses [15].

Statistical analysis

Data analysis was implemented using SPSS software version 28.0. Counting data were presented as percentages (%), analyzed using the chi-square (χ^2) test. Measurement data were expressed as mean and standard deviation (Mean ± SD), with the independent t-test applied for comparisons. $P<0.05$ was considered indicative of statistical significance.

Results

Comparison of baseline clinical data between two groups

The clinical data, such as gender, age, and body mass index (BMI), were compared between the two groups. This comparison revealed no statistically significant differences in these indices between the two groups ($P>0.05$), as illustrated in **Table 1** and **Figure 1**.

Table 1. Comparison of baseline data ($\bar{x} \pm s$)/[n (%)]

Clinical data		Research group (n=50)	Control group (n=48)	t/χ^2	P
Gender	Male	32	26	0.980	0.322
	Female	18	22		
Hypertension	Yes	10	6	1.008	0.315
	No	40	42		
Diabetes	Yes	6	5	0.062	0.804
	No	44	43		
Mean age (years)		56.32±12.56	55.98±11.98	0.137	0.891
Average BMI (kg/m^2)		22.32±2.13	21.98±2.81	0.677	0.500
Average hospitalization time (d)		18.69±6.13	19.65±5.81	0.516	0.441

BMI: body mass index.

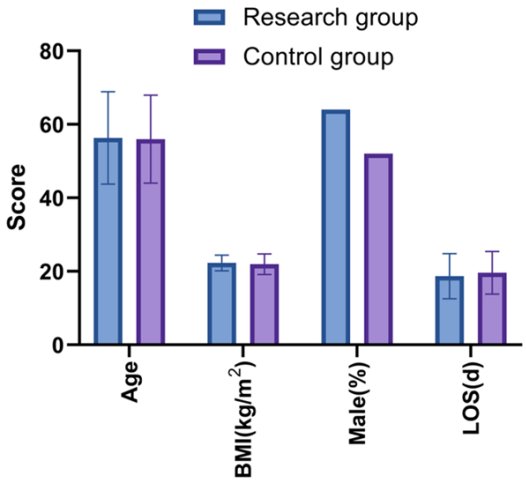

Figure 1. Comparison of baseline clinical data between the two groups.

Comparison of pulmonary function indices pre- and post-intervention

Lung function indices, namely FEV1 and LVEF, were collected at admission for both patient groups. Pre-intervention, these indices showed no significant differences between the two groups (P>0.05). Post-intervention, both FEV1 and LVEF levels demonstrated a significant increase compared with pre-intervention values. Notably, the research group exhibited higher FEV1 and LVEF levels compared with the control group (P<0.05) (**Figure 2**).

Comparison of sleep quality score pre- and post-intervention

Pre-intervention, the PSQI scores, including various dimensions and total scores, were collected for both groups, revealing no significant difference pre-intervention (P>0.05). However, post-intervention analysis showed that the PSQI scores and total scores of the research group were significantly lower compared with the control group, indicating better sleep quality (P<0.05) (**Figure 3**).

Comparison of serum inflammatory factor levels pre- and post-intervention

Pre-intervention, the serum CRP and PCT levels showed no statistically significant difference between the two groups (P>0.05). However, post-intervention, patients in the research group exhibited significantly lower CRP and PCT levels compared to the control group, exhibiting a statistically significant difference between the two groups (P<0.05) (**Figure 4**).

Comparison of quality of life score pre- and post-intervention

Quality of life, as measured by the SF-36 scale, was compared between the two groups both before and after intervention. Pre-intervention, no significant differences were observed between the two groups in terms of SF-36 dimensions and total scores (P>0.05). However, post-intervention, the SF-36 scores, both in various dimensions and total score, were significantly higher in the research group compared to the control group, indicating an improvement in quality of life (P<0.05) (**Figure 5**).

Analysis of risk factors for poor prognosis of COVID-19 patient

A multifactorial logistic regression analysis showed that non-receipt of cardiopulmonary rehabilitation, age ≥60 years, concurrent respi-

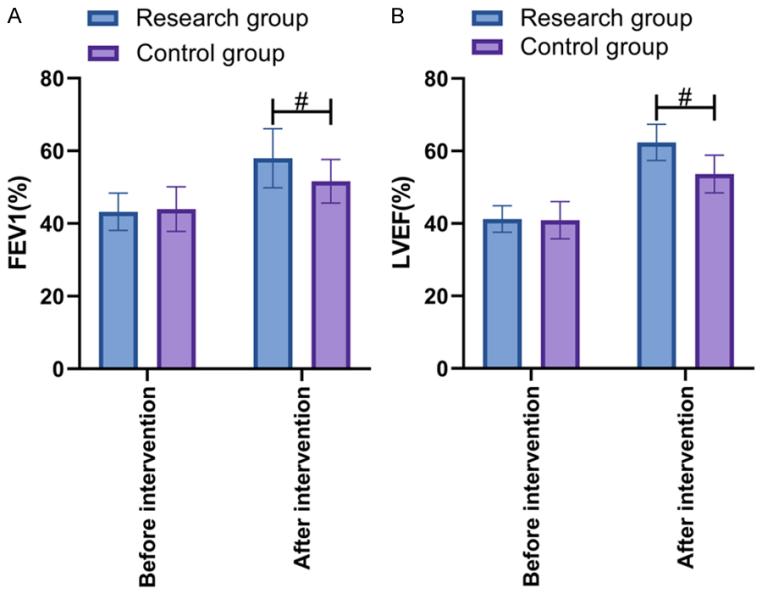

Figure 2. Pulmonary function indices before and after intervention. (A) depicts the pre-intervention similarity in FEV1 and LVEF levels across the groups (P>0.05), while (B) highlights the post-intervention enhancement in these indices within the research group compared to the control group (P<0.05). FEV1: Forced Expiratory Volume in 1 second; LVEF: Left Ventricular Ejection Fraction.

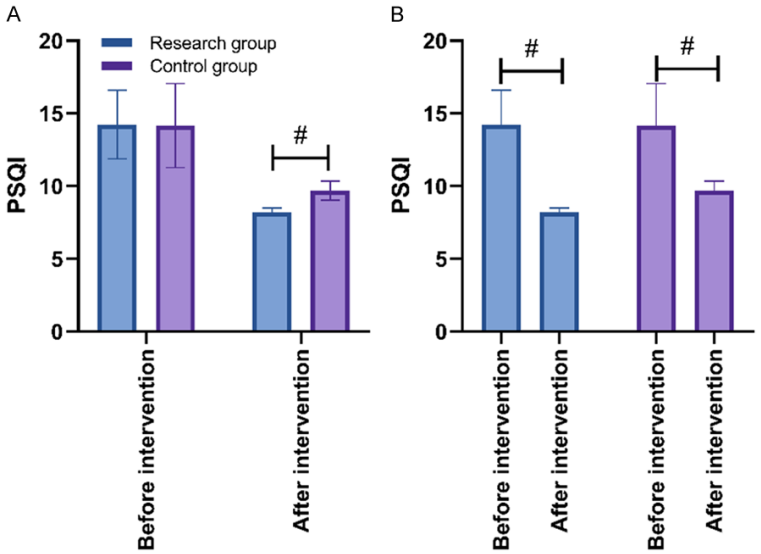

Figure 3. Comparison of sleep quality score pre- and post-intervention. In the pre-intervention phase, the analysis of PSQI scale scores indicated no significant difference between the groups (A) (P>0.05). However, in the post-intervention period, patients in the research group demonstrated lower scores in the total score of the PSQI scale compared to those in the control group (B) (P<0.05). #P<0.05. PSQI: Pittsburgh Sleep Quality Index.

ratory failure, coexistent heart failure, and acid-base imbalance were independent risk factors of adverse outcomes in COVID-19 patients (P<0.05) (**Table 2**).

Discussion

In December 2019, a series of inexplicable pneumonia cases emerged sequentially in several hospitals of Wuhan City, Hubei Province. Subsequent epidemiological investigations led experts to ascertain that this pneumonia was indeed an acute respiratory infectious disease, instigated by a novel coronavirus infection, specifically severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) [16]. The COVID-19 pandemic, as it came to be known, demonstrates potent transmission capabilities through direct, aerosol, and contact modes. The rapid global dissemination of this virus, within mere months, compelled the World Health Organization to designate COVID-19 as a global pandemic. The expansive and profound impact of the COVID-19 pandemic has been considered the most serious public health crisis of the 21st century. In May 2020, the State Council Joint Prevention and Control Mechanism of China issued the "Guidance Opinions on Normalizing Prevention and Control of the New Coronavirus Pneumonia Epidemic", marking a pivotal transition in China's approach to epidemic management from an emergency response to a normalized strategy, emphasizing prevention as the cornerstone [17]. Subsequently, the incidence of COVID-19 infections in China experienced a transient increase, but soon declined and stabilized. Clinical observations have shown that COVID-19 causes notable damage to the respiratory system. A majority of patients with COVID-19 reported diminished lung function and reduced exercise endurance post-infection. This debili-

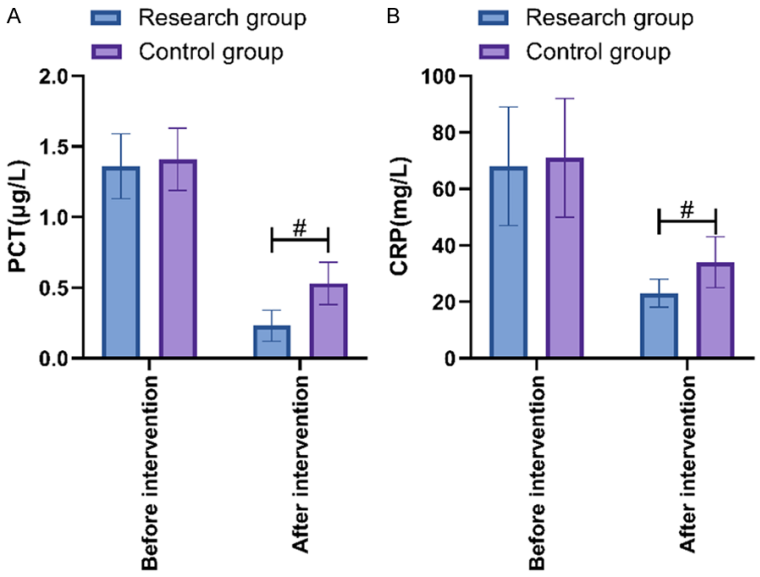

Figure 4. Comparison of serum inflammatory factor levels pre- and post-intervention. Pre-intervention, the serum PCT (A) and CRP (B) levels showed no statistically significant difference between the two groups ($P>0.05$). However, post-intervention, patients in the research group exhibited significantly lower PCT (A) and CRP (B) levels compared to the control group. $^{\#}P<0.05$. PCT: procalcitonin; CRP: C-reactive protein.

tation may be due to the viral-induced damage to the lungs. Currently, proactive prevention and post-infection rehabilitation are recognized as crucial determinants of enhancing the quality of life for COVID-19 patients [18, 19].

The authors of this study conducted a clinical analysis to evaluate the efficacy of cardiopulmonary rehabilitation nursing in the treatment of COVID-19 patients through grouping antitheses. The findings indicated that, compared with the control group receiving standard pneumonia care, patients in the research group receiving enhanced cardiopulmonary rehabilitation nursing exhibited a significant improvement in lung function post-intervention.

It has been established that the novel coronavirus (SARS-CoV-2) infiltrates cells via the angiotensin-converting enzyme 2 (ACE2) receptor, which are abundant in various human body parts, including the nasal mucosa, heart, gastrointestinal tract, liver, kidney, and brain. Consequently, SARS-CoV-2 can inflict damage on many of these organs [20]. Data from a follow-up study on COVID-19 patients pointed out that most patients with neocoronavirus pneumonia experienced a decrease in carbon monoxide diffusing capacity, total lung volume, expiratory volume with exertion in the first second, and exertional lung capacity about 1 month after the onset of the disease, which was attributed to the propagation of the neocoronavirus virus that disrupts the lung function of the patients, which in turn affects the aforementioned indexes [21]. A follow-up study on COVID-19 patients revealed a notable decline in several pulmonary function indices such as carbon monoxide diffusing capacity, total lung volume, forced expiratory volume in the first second, and forced vital capacity approximately one month post-onset, which was attributed to the fact that propagation of the COVID-19 virus disrupts the lung function of the patients, affecting the aforementioned indices [21]. This is similar to our findings. The data in this study revealed that post-affliction with COVID-19, patients exhibited significantly lower pulmonary function indicators, specifically FEV1 and LVEF, than normal values. Despite proactive nursing interventions, enrolled patients demonstrated a certain degree of improvement in pulmonary function indicators, yet it remained suboptimal. In contrast to control group patients receiving standard nursing, those in the research group undergoing cardiopulmonary rehabilitation nursing exhibited a more pronounced enhancement in pulmonary function indicators.

This study posits that COVID-19, as an acute respiratory disease, causes considerable damage to the lungs and respiratory tract upon entry and replication in the human body. This leads to endothelial damage, triggering substantial immune and inflammatory responses. Subsequently, patients may experience prolonged lung abnormalities and are at risk of respiratory distress. This may be linked to fibrotic changes, including the deposition of collagen and fiber-connecting proteins during the later stages of the inflammatory response [22]. Traditional nursing measures for COVID-19 often lack specificity and targeted effectiveness. In contrast, the cardiopulmonary rehabilitation

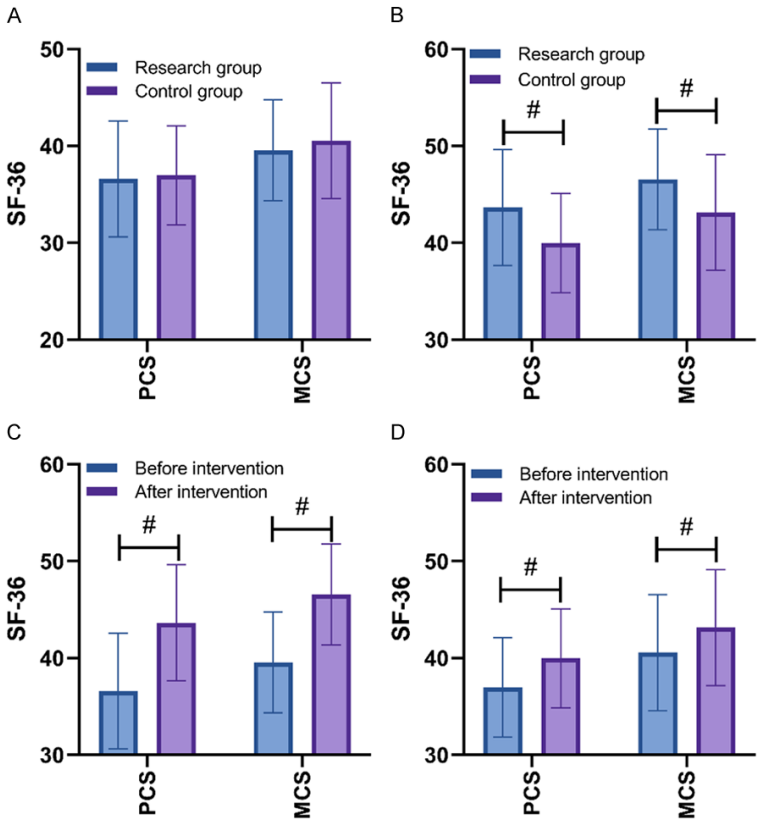

Figure 5. Comparison of quality of life score pre- and post-intervention. (A) shows the pre-intervention difference in SF-36 scores between the two groups ($P>0.05$). (B) illustrates the post-intervention superiority of the research group in total scores of the SF-36 scale ($P<0.05$). (C) shows the difference in the pre- and post-intervention SF-36 scores of the research group ($P<0.05$). (D) shows the difference in the pre- and post-intervention SF-36 scores of the control group ($P<0.05$). $^{\#}P<0.05$. PCS: Physical Component Summary; MCS: Mental Component Summary; SF-36: 36-Item Short Form Survey.

nursing adopted for the research group in this study was specifically tailored to enhance patients' lung function, psychological state, and respiratory capacity. Such rehabilitation exercises can facilitate sputum expectoration, reduce airway secretion accumulation, and improve the inflammatory response. Additionally, active rehabilitation exercises can enhance patients' exercise endurance and contribute to the improvement of their lung function. This aspect is also evidenced in the comparison of inflammatory factor levels between the two patient groups after intervention, confirming that proactive rehabilitative care interventions effectively ameliorated the inflammatory state of the patient's body.

In this study, the variations in sleep quality were additionally examined between the two patient groups post-intervention. The results demonstrated a significant enhancement in sleep quality among patients in the research group after intervention. Presently, it's acknowledged that novel coronavirus infection (COVID-19) can adversely affect the sleep quality of patients, leading to a condition termed "Coronasomnia" [23]. Clinical symptoms of Coronasomnia include difficulty in falling asleep, poor sleep quality, and reduced sleep duration.

Research of patients suffering from Coronasomnia indicates that poor sleep significantly impacts the psychological state and neurological function of patients. Prolonged poor sleep quality can trigger anxiety, depression, obsessive-compulsive symptoms, chest tightness, palpitations, diarrhea, and neurasthenia, all of which are detrimental to the recovery process of a COVID-19 patient [24]. A study on the sleep quality of COVID-19 patients indicates that due to factors such as diminished respiratory function and the impact of conditions like pain, COVID-19 patients had notably compromised sleep quality and frequently experienced difficulties in falling asleep and tend to awaken prematurely [25]. This is also mentioned in the present study, which indicated that, concerning the sleep assessment results for COVID-19 patients, the patients showed higher scores on various dimensions of the PSQI questionnaire before intervention. The authors of this study analyze that traditional nursing measures for COVID-19 have not fully acknowledged the role of good sleep in patient recovery. However, the sleep interventions implemented in this study, including creating a good sleep environment, actively correcting influencing factors, and necessary pharmacological interventions, effectively enhanced patients' sleep quality. This improvement lays a solid foundation for accel-

Table 2. Analysis of risk factors for poor prognosis in COVID-19 patient

Variable	β	SE	95% CI	OR	P
Absence of cardiopulmonary rehabilitation nursing	0.521	0.635	0.951-1.985	1.326	0.001
Age ≥60 years	0.362	0.256	0.961-2.115	1.322	0.005
Concurrent respiratory failure	0.359	0.259	0.841-2.551	1.536	0.005
Concomitant heart failure	0.365	0.256	0.781-2.154	1.425	0.006
Coexisting acid-base imbalance	0.369	0.259	0.845-2.561	1.512	0.006

COVID-19: Coronavirus Disease 2019; SE: standard error; 95% CI: 95% confidence interval; OR: odds ratio.

erating the recovery process of COVID-19 patients, as evidenced by the comparative analysis of the quality of life in both patient groups.

Implementing proactive cardiopulmonary rehabilitation nursing for COVID-19 patients is beneficial in enhancing their lung function, sleep quality, and overall quality of life, thereby positively influencing their prognosis. This approach holds significant potential for widespread application. Although this study validated the clinical value of cardiopulmonary rehabilitation nursing for COVID-19 patients to a certain extent, it is crucial to note that this is a retrospective analysis with a small sample size from a single center. Subsequent prospective studies with large samples and multiple centers will be conducted, so as to improve the detail of the research data.

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Disclosure of conflict of interest

None.

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