Effectiveness of Telemedicine Management in Pulmonary Rehabilitation for Elderly Patients with Stable Moderate-to-Severe Chronic Obstructive Pulmonary Disease: A Postprint of a Randomized Controlled Trial

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Abstract

Background: The population of patients with chronic obstructive pulmonary disease (COPD) in China is enormous. Pulmonary rehabilitation training, as a crucial component of stable-phase COPD management, can effectively improve patients' pulmonary function and quality of life, thereby reducing the burden on families and society. Foreign research data have demonstrated that pulmonary rehabilitation implemented under telemedicine management can improve patients' pulmonary function and quality of life (QOL) scores; however, relevant practice is still lacking domestically, particularly in western regions.

Objective: To evaluate the effects of combining respiratory rehabilitation training via telemedicine management with conventional therapy on ventilatory capacity and pulmonary function in elderly patients with moderate-to-severe COPD.

Methods: This study was a prospective randomized controlled trial. COPD patients who presented to Sichuan Provincial Fourth Hospital and five affiliated communities from June 2021 to June 2022 were consecutively enrolled. Simple randomization using a random number table was employed to assign patients to either an experimental group or a control group. The control group received conventional long-term regular inhaled bronchodilator and oral medication therapy, while the experimental group received telemedicine management in addition to the control group's treatment regimen. A six-month study was conducted on both groups, with pulmonary function, Borg scale scores, 6-minute walk test (6MWT), and QOL scores recorded at baseline and at 1, 3, and 6 months post-intervention.

Results: Study subjects were divided into a control group (72 cases) and an experimental group (73 cases). No statistically significant differences were observed between the two groups in gender, age, or baseline pulmonary function [percentage of forced expiratory volume in one second relative to predicted value (FEV1%pred) and ratio of forced expiratory volume in one second to forced vital capacity (FEV1/FVC)] (P>0.05). Time and group interaction effects were present for FEV1%pred, FEV1/FVC, 6MWT levels, and dyspnea and emotion domains of QOL scores (P<0.05). At 1, 3, and 6 months post-intervention, the experimental group's FEV1%pred, FEV1/FVC, Borg scores, 6MWT, and QOL scores were superior to those of the control group, with statistically significant differences (P<0.05). At 3 and 6 months post-intervention, the experimental group's FEV1%pred, FEV1/FVC, Borg scores, 6MWT, and QOL scores were superior to those at 1 month post-intervention (P<0.05).

Conclusion: Implementing respiratory rehabilitation through telemedicine management for elderly patients with stable moderate-to-severe COPD can effectively improve pulmonary function and enhance quality of life and survival quality in this patient population.

Full Text

Preamble

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Telemedicine Management in Stabilized Respiratory Rehabilitation of Elderly Patients with Moderate-to-Severe Chronic Obstructive Pulmonary Disease: A Randomized Controlled Study

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Abstract

Background: The number of chronic obstructive pulmonary disease (COPD) patients in China is substantial. Respiratory rehabilitation training, as a critical component of stable-phase COPD management, can effectively improve patients' lung function and quality of life while reducing the burden on families and society. International studies have demonstrated that respiratory rehabilitation implemented under telemedicine management can improve patients' lung

function and quality of life (QOL) scores. However, relevant practice remains lacking in China, particularly in western regions.

Objective: To assess the impact of respiratory rehabilitation training via telemedicine management combined with conventional therapy on ventilatory capacity and lung function in elderly patients with moderate-to-severe COPD.

Methods: This prospective randomized controlled study consecutively enrolled COPD patients from the Fourth People's Hospital of Sichuan Province and five affiliated community clinics between June 2021 and June 2022. Patients were randomly assigned to experimental and control groups using a simple randomization method with a random number table. The control group received conventional long-term regular inhaled bronchodilator and oral medication therapy, while the experimental group received telemedicine-guided respiratory rehabilitation in addition to the control group's treatment regimen. Both groups were followed for six months, with lung function, Borg score, 6-minute walk test (6MWT), and QOL scores recorded at baseline and at 1, 3, and 6 months post-intervention.

Results: The study included 73 patients in the experimental group and 72 in the control group. No significant differences were observed between groups in gender, age, or baseline lung function parameters [forced expiratory volume in one second as percentage of predicted value (FEV1%pred) and ratio of FEV1 to forced vital capacity (FEV1/FVC)] ($P>0.05$). Significant time-group interactions were found for FEV1%pred, FEV1/FVC, 6MWT levels, and QOL scores for dyspnea and emotional status ($P<0.05$). At 1, 3, and 6 months post-intervention, the experimental group showed superior FEV1%pred, FEV1/FVC, Borg scores, 6MWT results, and QOL scores compared to the control group ($P<0.05$). Within the experimental group, FEV1%pred, FEV1/FVC, Borg scores, 6MWT results, and QOL scores at 3 and 6 months were significantly better than at 1 month post-intervention ($P<0.05$).

Conclusion: Telemedicine-based respiratory rehabilitation for elderly patients with moderate-to-severe stable COPD can effectively improve lung function, quality of life, and overall well-being.

Keywords: Pulmonary disease, chronic obstructive; Rehabilitation; Breathing exercises; Respiratory function tests; Telehealth

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Introduction

Chronic obstructive pulmonary disease (COPD) is a chronic condition that severely impacts patients' quality of life and health status. Epidemiological studies indicate that COPD is a common disease in most countries worldwide, with a prevalence of 8-10%. According to relevant guidelines, respiratory rehabilitation plays a crucial role in COPD treatment alongside pharmacological management. Respiratory rehabilitation can significantly improve COPD symptoms, increase exercise capacity, and enhance quality of life, earning strong recommendations from the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines. However, the number of COPD patients receiving long-term respiratory rehabilitation remains relatively low. Studies show that less than 2% of hospitalized COPD patients in the United States undergo respiratory rehabilitation within six months, while a Chinese cross-sectional survey of 1,138 COPD patients reported a participation rate of only 24.69%. Low participation stems from limited rehabilitation resources, restricted social welfare benefits, and insufficient understanding of respiratory rehabilitation among healthcare providers and patients. Additionally, difficulties in frequent travel between hospitals and patients' homes result in inadequate supervision and guidance during stable phases, leading to poor treatment compliance.

Recent European and American studies have demonstrated that remote-guided rehabilitation can effectively improve treatment outcomes. However, whether this model can be replicated in western China remains unverified. This study proposes implementing a novel telemedicine-based respiratory exercise program under a tiered healthcare system, providing targeted sputum guidance and other support to assist COPD patients with respiratory rehabilitation and evaluate its clinical efficacy.

Methods

1.1 General Information

This prospective randomized controlled study consecutively enrolled 145 elderly stable COPD patients from the respiratory and critical care outpatient clinics of the Fourth People's Hospital of Sichuan Province and five affiliated community hospitals (Lion Mountain Community, Jingguanyi Community, Chenglong Community, Wufu Community, and Sanshengxiang Community) between June 2021 and June 2022. Patients were randomly assigned to experimental and control groups using simple randomization.

Inclusion criteria: (1) Met COPD diagnostic criteria according to the 2021 GOLD Report: Global Strategy for the Diagnosis, Management, and Prevention of COPD; (2) Stable disease assessment; (3) Age 65-80 years; (4) Normal cognitive function; (5) Informed consent; (6) Ability to complete 6MWT and routine pulmonary function tests; (7) Voluntary cooperation.

Exclusion criteria: (1) Combined severe cardiovascular or cerebrovascular diseases and/or hepatic or renal insufficiency; (2) Severe cognitive and/or psychological impairment; (3) Neurological or musculoskeletal disorders.

1.2 Treatment Methods

Both groups continued their pre-enrollment conventional medications, including long-term inhaled bronchodilators, oral mucolytics, theophylline agents, and montelukast. The experimental group additionally received telemedicine-guided respiratory rehabilitation based on assessment of patients' three-minute exercise capacity and breathing trainer endurance, with personalized rehabilitation plans developed accordingly. The respiratory rehabilitation program included breathing trainer use, exercise rehabilitation, breathing exercises, and sputum guidance, implemented through a novel three-tier telemedicine respiratory rehabilitation model. Regular patient education sessions were conducted at the hospital and community levels through on-site and remote video teaching, with healthcare providers supervising and recording patients' rehabilitation execution via remote visual systems daily. Community family physicians checked daily to ensure rehabilitation prescriptions were followed, with reminders sent through the remote visual system if omissions occurred.

Breathing trainer: The respiratory rehabilitation trainer produced by Guangzhou Tianxi Medical Technology Co., Ltd. (Guangdong Medical Device Registration No. 20212081397) was used [Figure 1: see original paper]. The device features a one-way valve, mouthpiece, supplementary measurement port, spring mechanism, and terminal knob. Physicians from our department's rehabilitation team provided specialized training to designated community rehabilitation physicians and regularly educated patients in the experimental group to ensure proper and effective device use. During the trial, patients used the breathing trainer three times daily, with five sets per session (five breathing trainer blows + two coughs per set), requiring vibration sound production.

Exercise rehabilitation: Our hospital's self-developed respiratory exercise program was employed for 10 minutes per session, primarily in standing position with some actions adaptable to sitting or lying positions based on physical condition. The program combined limb movements with pursed-lip breathing and abdominal breathing to improve ventilation, enhance oxygenation, and promote effective sputum expectoration. Monthly joint hospital-community patient education sessions included on-site and remote video teaching, requiring experimental group patients to perform exercises once daily with supervision.

Breathing exercises: To assist patients with difficulty standing, this study

adopted the supine breathing exercises from the First Affiliated Hospital of Guangzhou Medical University. Patients could lie flat in bed and perform a series of movements to strengthen respiratory muscles, improve respiratory endurance, and reduce dyspnea. Monthly joint hospital-community patient education sessions included on-site and remote video teaching, requiring experimental group patients to perform breathing exercises once before bedtime with supervision.

Sputum guidance: Through offline and online remote patient education, patients were instructed in effective coughing and sputum expectoration techniques: sit with body leaning slightly forward, use a pillow to support the abdomen and assist diaphragm control, combine pursed-lip and abdominal breathing, exhale slowly and fully, then inhale slowly and deeply, hold breath for 3-5 seconds at the end of inhalation, initiate 2-3 short forceful coughs from the chest, then expectorate. Patients could press both hands on the upper abdomen to assist abdominal muscle contraction. The technique was required at least once daily, with community physicians adjusting guidance based on patients' sputum conditions. Family members were instructed to assist with hollow-palm percussion for effective sputum expectoration.

1.3 Evaluation Indicators

Both groups were studied for six months, with lung function, 6MWT, Borg score, and QOL scores recorded at baseline and at 1, 3, and 6 months post-intervention.

Lung function: The same technician from our hospital's respiratory department used the same brand of remote spirometer (Chengyi Family Technology [Tianjin] remote portable spirometer) to train community physicians, requiring passing assessment. A unified assessment form was developed by our department, with one optimal candidate selected from each community. Hospital follow-up patients underwent testing with Chengyi Family Company's remote spirometer (Tianjin) by the same technician. For community follow-up patients, each community designated a single technician to measure FEV1%pred and FEV1/FVC using the same brand remote spirometer.

Borg score, QOL score, and 6MWT: These were assessed by the same physician. The Borg score, from the first edition of *Respiratory Medicine Terminology*, is a commonly used method for evaluating dyspnea severity. QOL scales are widely applied in clinical trials, health surveys, and medical intervention effectiveness evaluations. These scales are categorized as generic or disease-specific based on whether they target specific diseases or symptoms. Generic scales can be used across various populations without disease limitation, offering broader applicability and stronger result comparability. This study employed a generic QOL scale comprising five domains: dyspnea, activity capacity, emotional status, household work, and appetite, enabling assessment of patients' quality of life and health status while assisting in determining acceptable rehabilitation

approaches.

6MWT: A 30-meter wide, flat path with marked measurements was established. Participants walked from one end to the other and back, turning around at each end. If participants felt unwell and could not continue, they were permitted to rest but were encouraged to resume walking as soon as possible. The total distance walked at the end of 6 minutes was recorded.

1.4 Statistical Analysis

A database was established using Windows Excel software. SPSS 17.0 statistical software was used for data processing. Normally distributed measurement data were expressed as ($\bar{x}\pm s$). Independent samples t-tests were used for between-group comparisons, and repeated measures ANOVA was used for multi-timepoint data. The Huynh-Feldt coefficient method was used for sphericity correction, and LSD-t tests were used for pairwise between-group comparisons. Count data were expressed as relative frequencies and compared using ^{2} tests. $P<0.05$ was considered statistically significant.

Results

2.1 Baseline Data

The experimental group comprised 73 patients (44 male, 29 female), while the control group comprised 72 patients (41 male, 31 female). No significant differences were observed between groups in gender, age, or baseline lung function parameters (FEV1%pred and FEV1/FVC) ($P>0.05$) .

2.2 Comparison of Lung Function, Borg Score, and 6MWT

Significant time-group interactions were found for lung function, 6MWT levels, and QOL scores for dyspnea and emotional status ($P<0.05$). At 1, 3, and 6 months post-intervention, the experimental group demonstrated superior FEV1%pred, FEV1/FVC, Borg scores, 6MWT results, and QOL scores compared to the control group ($P<0.05$). Within the experimental group, FEV1%pred, FEV1/FVC, Borg scores, 6MWT results, and QOL scores at 3 and 6 months were significantly better than at 1 month post-intervention ($P<0.05$) [TABLE:2-3].

Before intervention, no significant differences existed between groups in lung function, Borg scores, or 6MWT levels ($P>0.05$). At 1, 3, and 6 months post-intervention, significant differences were observed between groups in these parameters ($P<0.05$). Within the experimental group, lung function, Borg scores, and 6MWT levels at 3 and 6 months were significantly improved compared to 1 month post-intervention ($P<0.05$).

2.3 QOL Score Changes

Significant time-group interactions were observed for dyspnea and emotional status in QOL scores ($P<0.05$), but not for activity capacity, household work, or appetite ($P>0.05$). Time showed significant main effects on dyspnea and emotional status ($P<0.05$), while group showed significant main effects on all QOL domains: dyspnea, activity capacity, emotional status, household work, and appetite ($P<0.05$). Time did not show significant main effects on activity capacity, household work, or appetite ($P>0.05$).

Before intervention, no significant differences existed between groups in any QOL domain scores ($P>0.05$). At 1, 3, and 6 months post-intervention, significant differences were observed between groups in all QOL domains ($P<0.05$). Within the experimental group, QOL domain scores at 3 and 6 months were significantly improved compared to 1 month post-intervention ($P<0.05$) [TABLE:4-5].

Discussion

COPD is clinically characterized by irreversible airflow limitation, with high incidence, predominant occurrence in elderly populations, significant impact on daily life, and high mortality. China has nearly 100 million COPD patients. Respiratory rehabilitation training, as a crucial component of stable-phase COPD management, can effectively reduce dyspnea and wheezing symptoms, increase exercise endurance, decrease acute exacerbation frequency, and reduce medical costs and mortality. Previous studies have found that combining conventional treatment with early respiratory rehabilitation yields more significant benefits for stable COPD patients. Respiratory rehabilitation can alter breathing patterns, improve respiratory muscle utilization, effectively enhance pulmonary ventilation and gas exchange capacity, increase oxygen supply, improve circulatory muscle contractility, and boost exercise endurance. Therefore, investigating remote respiratory rehabilitation and establishing a system adapted to China's national conditions represents a future research trend and mission. Various policy measures can promote remote rehabilitation for chronic lung disease patients, including family physician contract services, chronic disease-specific care, medical insurance support, and social welfare. Additionally, leveraging tiered healthcare systems with wearable devices and 5G+ big data can enable more accurate data transmission and analysis, helping healthcare providers better assess, supervise, treat, and communicate with stable-phase patients in real-time, thereby improving remote respiratory rehabilitation outcomes.

Previous healthcare models primarily focused on acute-phase COPD treatment, which is insufficient. This study has confirmed the multiple benefits of rehabilitation during stable phases. However, barriers remain in implementing remote respiratory rehabilitation, including patients' lack of understanding of telemedicine, concerns about new technologies, and fear of treatment. COPD patients are predominantly middle-aged and elderly individuals with slower fin-

ger operations, decreased dexterity, and impaired vision, hearing, and cognitive abilities. Additionally, data generated through telemedicine technologies may not receive timely analysis and feedback, potentially leading to treatment discontinuation.

This study evaluated lung function, 6MWT, Borg scores, and QOL scores—outcome measures from different dimensions designed to assess the multifaceted impact of respiratory rehabilitation on COPD patients. The 6MWT and lung function can measure pulmonary function improvement before and after respiratory rehabilitation, while Borg and QOL scores can assess symptom and quality-of-life improvements. This study conducted repeated measurements at three timepoints (1, 3, and 6 months post-intervention). Following comprehensive respiratory rehabilitation under tiered healthcare system intervention, the experimental group showed superior lung function, 6MWT, Borg scores, and QOL scores at all three timepoints compared to the control group, with statistically significant between-group differences and time effects, indicating interactive influences. These results demonstrate the efficacy of comprehensive respiratory rehabilitation under tiered healthcare system intervention.

This study aimed to establish a comprehensive, tiered healthcare-based, sustainable, and condition-specific COPD treatment program through video calls, portable medical devices, and remote spirometry assistance, creating a complete hospital-community-patient closed loop that is accurate, reliable, widely accessible, adapted to China's national conditions, and adjustable based on disease severity to provide more personalized treatment effects, offering certain advantages in stable-phase COPD respiratory rehabilitation management. Although this study had a limited sample size and did not account for factors such as patients' nutritional status and living environment, it still provides valuable information for clinicians. Future research should expand sample sizes, improve inter-institutional cooperation methods, and incorporate patients' lifestyle and dietary habits.

Author Contributions: Yuan Quan and Lu Haiying conceptualized the research direction. Yuan Quan and Liu Yunxiao organized case data and drafted the manuscript. Yu Jiaqin, Tian Fengzhao, and Li Yao collected case data. Wang Yi organized the data. Yuan Quan, Liu Yunxiao, and Wang Yi were responsible for quality control and revision, with overall responsibility for the article. Lu Haiying supervised research planning and execution. All authors approved the final manuscript.

Conflict of Interest: The authors declare no conflicts of interest.

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