

A Randomized Controlled Study of Muscle Training Exercise Based Pulmonary Rehabilitation on Activity of Daily Living in Patients with Coronavirus Disease 2019

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Abstract

Background: Hospitalized patients with Coronavirus Disease 2019 (COVID-19) pneumonia showed a severe loss of muscle mass and strength over admission. Therefore, early physical interventions might be conducive to prevent disability and fasten recovery.

Methods: We designed a prospective, randomized controlled trial to identify the effectiveness and safety of pulmonary rehabilitation based on muscle exercise in COVID-19 patients. The study was conducted between February 7th and March 31st 2020 in Union Hospital. Patients were randomly assigned to the pulmonary rehabilitation exercise group or the control group. Primary outcome was improvement of activity of daily living (ADL). Secondary outcome was changes of muscle strength assessed by manual muscle test (MMT) and arterial blood gas analysis. Length of hospital staying (LOS) and adverse events related to physical activity were also observed.

Results: A total of sixty patients were in analysis, and thirty patients were in PR group. Patients had a mean age of 54.43 ± 10.57 years. A statistically and clinically significant increase in ADL was observed in PR group (75.00 [66.25,90.00] to 100.00 [100.00,100.00], $p < 0.001$). We also found that the improvement of ADL was related to younger age and higher PaO_2 ($p < 0.01$). Both groups had MMT improvement and there was no statistical difference between groups. There was a significant increase in PaO_2 (80.23 ± 6.49 vs. 90.47 ± 7.82 , respectively, $p < 0.001$) between two groups before discharge. There was no statically significant difference in LOS between study group and control group ($p = 0.62$). None of these patients had severe complications during the study.

Conclusions: The protocol of pulmonary rehabilitation based on muscle training exercise was feasible in COVID-19 patients and it might accelerate recovery in ADL as compared with the spontaneous recovery in the control group.

Clinical Trial Registration: ChiCTR, ChiCTR2000032457. Registered 29 April 2020- Retrospectively registered, <http://www.chictr.org.cn/showproj.aspx?proj=52925>.

Introduction

Coronavirus disease 2019 (COVID-19), a highly infectious respiratory disease, has become the world's leading health problem and caused major public concerns¹. Since the outbreak of a novel coronavirus epidemic resulting in COVID-19 on December of 2019, a total number of 7,553,182 patients has been confirmed in more than 200 countries until Jun. 13th.² And it is expected to rise even higher as reports from health authorities. However, there is no evidence for effective treatment or intervention for COVID-19 currently.

COVID-19 leads to respiratory dysfunction and muscle weakness,³ and patients may suffer from respiratory failure.^{4,5} Physical and psychological problems of patients have been concerned, especially in recovery stage, so physical therapy has been proposed for patients with COVID-19. Pulmonary rehabilitation is an important intervention for chronic respiratory disease. It was expected that the pulmonary rehabilitation could relieve symptoms and improve functional performance of patients with COVID-19 in recovery stage.

To our knowledge, there are few researches on pulmonary rehabilitation of patients with COVID-19. In this study, we proposed a prospective, randomized controlled trial, aiming at exploring the effectiveness and safety of pulmonary rehabilitation based on muscle training exercise for adult COVID-19 patients. Considering the clinical characteristics of COVID-19 and the conditions of the isolation ward, we designed a set of special pulmonary rehabilitation based on the exercise program widely adopted in clinical practice, including Zheng's supine rehabilitation exercises.⁶

Methods

Study design and participants

The study was a prospective, randomized controlled trial. Patients were enrolled from Union Hospital, Tongji medical college, Huazhong university of science and technology (Wuhan, Hubei Province of China) between February 7th, and March 31st, 2020. Pulmonary rehabilitation program was taken place in department of respiratory and critical care medicine, in a medical college affiliated teaching hospital. This study was approved by the Institutional Review Board of Wuhan Union Hospital (project approval number 2020-0127), and participants provided written informed consent.

Randomisation was conducted at the trial centre and the participants were randomly allocated to either the pulmonary rehabilitation exercise group or the control group at a ratio of 1:1. Pulmonary rehabilitation exercise group assignments were generated using Statistical Product and Service Solutions (SPSS) 25.0 software (IBM Corp., Armonk, NY, USA) and communicated using sealed opaque envelopes.

Eligible patients were those who were diagnosed as COVID-19 and were admitted to the hospital during the study. Inclusion criteria including: (1) patients aged from 18 to 70 years; (2) patients whose percutaneous oxygen saturation (SpO₂) > 90% while the patients breathed ambient air or had oxygen support. (3) patients who were consciousness and could follow instructions. (4) patients whose disease onset > 2 weeks and had been hospitalized > 72 hours.

Exclusion criteria including: (1) pregnant women; (2) unstable coronary heart disease; (3) mean blood pressure < 60mmHg, or blood pressure > 140/90 mmHg; (4) peak temperature > 38°C; (5) unstable hemodynamics; (6) deep venous thrombosis; (7) severe hepato-renal dysfunction; (8) mental disorders or learning disability; (9) patients who couldn't take at least seven days of pulmonary rehabilitation program.

Criteria of discharge: (1) Normal temperature > 3 days; (2) Respiratory symptoms improved significantly; (3) Pulmonary imaging showed that acute exudative lesions were absorbed obviously; (4) The 2019 nCov nucleic acid test of sputum, nasopharynx swab or other respiratory samples was negative twice (sampling time should have an interval of at least 24hours).

Data collection

Baseline data of all patients were collected, including demographic (age and sex, height, weight, body mass index), general condition, symptoms, comorbidities, vital signs (body temperature, heart rate, respiratory rate, and blood pressure), laboratory tests (blood routine test, arterial blood gas analysis (ABG)), chest computed tomography scan, Barthel activities of daily living (ADL) scores⁷ and manual muscle test (MMT). Medical and respiratory support, complications, and outcomes were also analysed. Vital signs, rating of perceived exertion scale (RPE)⁸ and SpO₂ were recorded prior to and after physical rehabilitation exercise. Data of symptoms, MMT and arterial blood gas analysis were recorded before discharge. Data of ADL was recorded after 7days of after exercise and before discharge and SpO₂ was recorded after 3days and 7days of after exercise and before discharge.

Assessment Measures

Barthel ADL was modified in 1988 to a 20 point scale that measures in increments of 1 point, which was from 0 (fully dependent) to 20 (fully independent). The final score could be multiplied by 5 to obtain a 100 point score, and it was proposed that scores of 0–20 indicating “total” dependency, 21-60 indicating “severe” dependency, 61–90 indicating “moderate” dependency, and 91–99 indicating “slight” dependency. The Barthel ADL assessment comprised: feeding, grooming, bathing, dressing, toilet use, presence of fecal incontinence, presence of urinary incontinence, transfers (e.g. moving from wheelchair to bed), walking on an even surface (or propelling a wheelchair if unable to walk), and ascending and descending stairs. It was already widely used as the measurement of daily living activities and had become a standard measure of physical disability in clinical practice⁷.

RPE scale was a 15-point scale, ranging from 6 to 20 (corresponds to an approximate heart rate between 60 and 200), designed to estimate how heavy and strenuous the work is perceived⁸.

Scoring of the manual muscle testing(MMT): Grade 0: no contraction of the tibialis anterior. Grade 1: visible contraction of the tibialis anterior,Grade 2: active movement with gravity eliminated. Grade 3: active movement against gravity. Grade 4: active movement against gravity and moderate resistance. Grade 5: normal response (against gravity with full resistance).

Intervention

Respiratory support and medication treatment was applied to each patient, which was consistent with the guide for the prevention and treatment of coronavirus disease 2019⁹. Each patient received supportive treatment. The pulmonary rehabilitation program based on muscle training exercise, including bedside exercises for patients who were able to stand, and in-bed exercises for those patients who were bedridden. Procedures of exercise training are detailed further in e-Appendix 1. Patients who were able to stand, took step 1 to step 6 program, which respiratory muscle, torso and limb movements were designed in different positions. For those patients who were bedridden, took step 1 to step 3 program, movement of upper and lower limbs and the change of body position were implemented to all.

Breathing rehabilitation would take 15 minutes each time, twice a day. Patients who took inbed or bedside exercise depended on the decision of doctor. Patients who had a RR<28, HR<100, and lower limb MMT>4 would preferred bedside exercise. Whether patients performed muscle training exercise and pulmonary rehabilitation under O₂ therapy decided by SpO₂ during exercise. In the course of rehabilitation, patients followed original respiratory support, and adjust the level of respiratory support according to the change of SpO₂, making ensure that SpO₂ > 88% could be maintained in the course of rehabilitation. It should be terminated if SpO₂ could not be maintained above 88%. The program was performed by two respiratory therapists in intervention group, and supervised by a physician. Each patients took at least seven days of pulmonary rehabilitation program based on muscle training exercise. In control group, no special exercise training were guided by doctors.

In the process of muscle training exercises, once one of the following situations occurred, the patient should immediately stop exercising:¹⁰ (1) Borg scale > 3 (10 points in total); (2) one of the symptoms: chest tightness, dyspnea, dizziness, headache, unclear vision, palpitation, sweating, inability to maintain balance, pain (chest pain, strong headache or strong abdominal pain) or fatigue; (3) other situations which clinicians judged that were unsuitable continuing pulmonary rehabilitation: heart rate < 40 or > 130 beats/min; mean blood pressure < 65mmHg or > 110mmhg, or more than 20% change from baseline; respiratory rate: > 40 times/min or < 5 times / min; SpO₂ ≤ 88% or decrease > 4%; new arrhythmia; new myocardial ischemia or unstable angina.

Outcomes evaluation

Primary outcome was improvement of ADL following pulmonary rehabilitation before enrollment and before discharge. Intra-group and inter-group comparisons were conducted. Secondary outcome were changes of MMT, ABG and length of hospital staying (LOS). Adverse effects of pulmonary rehabilitation were also analysed during pulmonary rehabilitation program.

Sample Size

Since the COVID-19 was considered as a new disease, there was no reference data for pulmonary rehabilitation. Sample size was calculated based on our pilot study. In the previous work, we carried out pulmonary rehabilitation exercise on 5 patients, and observed their symptom changes and ADL score improvement. Meanwhile, We also referred to data based on community-acquired pneumonia patients, which previously reported by Anderson J and Simone DC.¹¹ We estimate a 35% improvement in ADL score between the pulmonary rehabilitation group and control group with a two-sided test size of 5% and power of 80%. 27 eligible participants were required per study arm. Considering that about 10% of the enrolled cases might dropped out of the study, we finally set the sample size as 60 cases, with 30 cases in the pulmonary rehabilitation group and 30 cases in the control group. The sample size was determined using SPSS 25.0 software.

Statistical analysis

SPSS 25.0 software was used for the statistical analysis. Results are expressed as mean±SD for variables normally distributed and abnormally distributed data were expressed as median (IQR). For primary and secondary outcome, intra-group comparisons of quantitative data were done using the paired Student's *t* test or Wilcoxon rank test for variables which were not normally distributed. Inter-group comparisons were done using unpaired Student's *t* tests or with Mann-Whitney *U* test for variables non-normally distributed. Categorical variables were compared using χ^2 tests or Fisher test. Correlation analyses between two ADL and variables were done by Spearman correlation. P value <0.05 indicated a statistically significant difference.

Results

A total of sixty COVID-19 patients were enrolled in this study. Sixty patients were in the final analysis including 34 males and 26 females. (The flow of participants recruitment in this study was showed in Figure 1). Thirty patients were in pulmonary rehabilitation exercise group and thirty patients were in control group.

There were no significant difference of sex between two groups (16 males vs. 18 males, retrospectively, $p=0.602$). Participants had a mean age of 54.43 ± 10.57 years. The mean time of starting pulmonary rehabilitation exercise after hospitalization was 12.28 ± 10.31 days and the average time of patients taking physical rehabilitation exercise was 14.39 ± 5.05 days. There were no significant differences of symptoms, past history and regular treatment between two groups. No statistically significant differences of vital signs of patients and arterial blood gas analysis were observed between two groups. (Demographic and parameters of baseline were presented in Table 1, and Table 3).

After the exercise program, a statistically and clinically significant increase in ADL was observed in pulmonary rehabilitation exercise group (75.00 [66.25,90.00] vs. 100.00 [100.00,100.00], $p<0.001$). Increases of ADL in both groups were statistically significant, but almost twice greater improvement was observed in pulmonary rehabilitation exercise group (17.50 [10.00, 30.00]), when compared with control group (10.00 [10.00,10.00]) ($p<0.001$) (Figure 2). The between-group comparisons of ADL and MMT following physical rehabilitation exercise before discharge were showed in table 2.

Before discharge, we observed no significant differences between two groups for MMT assessed by mMRC in pulmonary rehabilitation exercise group and control group (5.00 [5.00, 5.00] vs. 5.00 [5.00, 5.00], respectively). However, both groups increased MMT. Respiratory rate was lower in pulmonary rehabilitation exercise group than control group in statistically significance ($p=0.005$), but there was no significant clinical meaning. Although there was no statistical difference of LOS, we observed a trend of shorter hospital staying time in pulmonary rehabilitation exercise group (23.00 days [14.00,30.25] vs. 21.00 days [16.50,33.25], $p=0.62$).

There were no significant differences in the arterial blood gas analysis between the two groups before enrollment ($p>0.05$), but there was a significant increase in PaO_2 (80.23 ± 6.49 vs. 90.47 ± 7.82 , respectively, $p<0.001$) between the control group and the pulmonary rehabilitation exercise group before discharge (Table 2). Patients in the pulmonary rehabilitation exercise group had more improvement of PaO_2 and SpO_2 than in the control group. SpO_2 significantly increased after seven days and before discharge (Figure 3).

In total subjects, the improvement of ADL was significantly related with pulmonary rehabilitation based on muscle training exercise, younger age ($r= -0.551$, $p<0.01$), higher PaO_2 ($r=0.539$, $p<0.01$). Sex, BMI, smoking, concomitant medical history, and oxygen therapy were not related to ADL in correlation analysis.

Complications of pulmonary rehabilitation based on muscle training exercise

It showed that pulmonary rehabilitation based on muscle training exercise in COVID-19 patients was well tolerated. Data on adverse events related to the intervention was mild, and could relieve after termination of activity. The proportion of participants who had adverse events was 13.3% (4 patients) in the study intervention and none of them quitted the clinical trial. Two participants suffering from dyspnea and palpitation, while one patient with sweating during exercise on the first

day, and symptoms relived after stopping exercise. While in the next day, patients continued exercise with no symptoms reported. One participants who reported lower SpO₂, higher HR and dyspnea on the third day during the study period, and SpO₂ rose when they had oxygen therapy and continued the physical rehabilitation program. None of these patients had severe complications during the study. In the control group, two patients had deep venous thrombosis and one patient suffered secondary bacterial infection during the observation.

Discussion

To our knowledge, this is the first randomized control study to evaluate pulmonary rehabilitation in COVID-19 patients, in which we demonstrated that more than one week pulmonary rehabilitation program in COVID-19 could improve patients life activity. Meanwhile, we found a relatively shorter LOS in pulmonary rehabilitation group.

Although pulmonary rehabilitation is a routine therapy in chronic respiratory disease, there is no evidence to support the routine use of patients who are hospitalized for community-acquired pneumonia (CAP). Long before, a randomized clinical trial examined chest physiotherapy in CAP, but failed to demonstrate improvements in fever, LOS, or mortality.¹² A systematic review and meta-analysis of adjunctive therapies for patients hospitalized for CAP showed that clinical trials with pulmonary rehabilitation therapy were few and could not provide evidence of benefits from routine use.¹³ Until recently, studies showed that an integrated program of physical therapy during hospitalization could improve physical and functional performance in patients with pneumonia.^{11,14}

For patients who have severe pneumonia and stay in bed for a long time, hospital acquired muscle weakness and muscle atrophy frequently occur. After discharge, the most common complications of patients with acute respiratory distress syndrome are exercise restriction and decline of life quality, which can last for 5 years.^{15,16} These patients may have difficulties in climbing up stairs, bending down, lowered functional exercise capacity, and other activities difficulties in daily life.¹⁵ Functional exercise in pulmonary rehabilitation can effectively reduce muscle atrophy and improve body functions, including muscle strength, endurance and functional activities.¹⁷

As a highly infectious respiratory disease, pulmonary rehabilitation methods should follow the principle of 4S in COVID-19, which is simple, satisfy, safe and save,⁶ in order for patients easily to manipulate. Meanwhile, establishment of a safe pulmonary rehabilitation environment to prevent the spread of virus should be concerned. Rehabilitation outcome is closely related to participation initiatives, environmental and personal factors. In clinical practice, there are many reasons for poor compliance, thus, we took appropriate interventions to help patients actively participating before pulmonary rehabilitation.

Zhou L observed that about three to five percent of common type COVID-19 patients might aggravate to severe type in 7 to 14 days of disease onset.¹⁸ We evaluated time of disease onset to dyspnea and monitor patients SpO₂, heart rate, respiratory rate, blood pressure and symptoms to decide the initiation time of pulmonary rehabilitation program. Meanwhile, according to the patient's condition, we designed a set of special pulmonary rehabilitation program, including upper and lower limbs exercise, body position training and breathing rehabilitation. As excessive exercise training may lead muscles injury, resulting in excessive fatigue, we estimated the patient's training intensity by symptoms, vital signs, Borg index and RPE scale.

It was found in this trial that the ADL of the patients with COVID-19 in pulmonary rehabilitation group were notably better than those of the patients in control group. Pulmonary rehabilitation is a pattern of combined treatment for patients' exercise capacity, recovery of pulmonary function and psychology.¹⁹ Previous study showed that, pulmonary rehabilitation therapy has positive effects on improvement of patients with chronic obstructive pulmonary disease (COPD) in physical activity in daily life level.²⁰ Meantime, our study showed that improvement of ADL was related to younger age, higher PaO₂, and lower mMRC. Since an observation data showed that the younger patients, the greater the probability of functional recover would get.¹⁶ Therefore, elderly patients might need different intensity or form of pulmonary rehabilitation program to achieve similar effects as young patients.

In this research, we found that dyspnea, measured by mMRC, improved in both groups of patients; but there was a significant between-group difference, with pulmonary rehabilitation group better improved in mMRC. This may be because functional exercise could increase muscle strength, which was also demonstrated in current study. As we know, the improvement in respiratory muscle strength is important for patients' life quality. The therapy is an important part of management of patients with respiratory disease, and physical training plays an active role in improving exercise capacity and dyspnea.^{21,22}

The COVID-19 has a great influence on the patients' psychology. In the clinical process, symptoms of the patients are heavier, while the oxygen and the condition are good. So it is not objective to evaluate the patients condition according to symptoms. Conventional treatment assisted by comprehensive pulmonary rehabilitation therapy has positive effects on PaO₂ with COVID-19 pneumonia patients. Therefore, blood gas analysis of the patients with COVID-19 were evaluated in this study, and the results proved that the pulmonary rehabilitation had remarkable improvement in the patients PaO₂ and SaO₂. It was consistent with the results of the study by Liu W, et al²³ in patients with severe pneumonia that physical therapy could ameliorate the blood gas indexes. The pulmonary rehabilitation could effectively improve the blood gas indexes of patients with chronic obstructive pulmonary disease in the stable phase, too.²⁴ These results have proven that the pulmonary rehabilitation had improvement effects on the the exchange capacity of oxygen in patients.

Pulmonary rehabilitation therapy could improve the respiratory function reserve²⁵ and ameliorate the patients' cardiopulmonary functions.⁶ Exercise rehabilitation commenced during acute or critical illness reduced the extent of functional decline and hastens recover.²¹ A study conducted by Mundy LM, et al²⁶ found that early mobilisation could reduce LOS. However, No significant difference of LOS was found between groups in our study, though pulmonary rehabilitation group patients exhibited a trend of shorting LOS. This divergence may have occurred because the LOS in the present study depended on several factors, such as negative test of 2019-nCoV RNA-PCR test, absorption of chest images, other than only clinical criteria.

There were no severe complications of related to pulmonary rehabilitation group. No patients discontinued the trial. As the patients included in this trial were severe type in recovery stage, adverse events related to pulmonary rehabilitation are few and can be accepted. And the appropriate indication needs further research. In the control group, two patients complicated with DVT. Coagulation dysfunction can occur in patients with COVID-19, and a significant proportion of patients with coagulation disorders have DVT, which have been reported in 25% of cases²⁷. We speculate that pulmonary rehabilitation exercise might reduce the risk of occurrence of thrombus through the movement of upper and lower limbs and changes of body position. But this needs larger sample clinical research.

Both groups received normal daily care during the hospitalization period, including drug treatment and oxygen therapy adjusted by the medical staff. All patients were discharged, therefore there was no association between mortality and pulmonary rehabilitation program. This was due to that very severe patients with multi-organ dysfunction were not included, which may correspond to prognosis of a low degree of lethality.

The application of pulmonary rehabilitation program could improve ADL and dyspnea in this group of patients, but some limitations have to be taken into consideration. Firstly, because of limitation of the isolation ward, six-minute walk distance and pulmonary function were not conducted. Secondly, the sample of subjects in this research was small, therefore, enrolled with more patients of multicenter, randomized controlled trials, with appropriate follow-up of are needed.

Conclusion

Exercise protocol might speed-up recovery in ADL as compared to the spontaneous recovery as observed in the control. Pulmonary rehabilitation is feasible, safe and without increasing economic burden. Therefore, more extensive, standardized studies would be necessary to confirm the clinical and functional benefits of pulmonary rehabilitation in COVID-19 patients.

List Of Abbreviation

ADL: activities of daily living; BMI: body mass index; COVID-19: Coronavirus Disease 2019; LOS: length of hospital staying; MMT: manual muscle test; PaO₂: partial pressure of oxygen; PR: Pulmonary rehabilitation; RPE: rating of perceived exertion scale; SpO₂: percutaneous oxygen saturation

Declarations

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Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Authors' Contributions

ZRT, JZZ, ZLZ, FW and YL substantial contributions to the conception or design of the work; XNL, YR, FW and SL conducted the randomized controlled trial and data collection. ZLZ and DDC takes responsibility for the integrity of the data and the accuracy of the data analysis. ZLZ, FW, XW and XYZ contributed substantially Manuscript writing. All authors approved the final version of manuscript. ZRT and JZZ reviewed the manuscript critically for important intellectual content and final approval of the version submitted for publication.

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of Wuhan Union Hospital (project approval number 2020-0127), and participants provided written informed consent.

Consent for publication

Not applicable.

Competing interests

The author reports no conflicts of interest in this work.

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Tables

Table 1. comparisons of baseline variables between the two group

Variables	Control group(N = 30)	PR group(N = 30)	p-value
Age (years)	56.10 ± 11.54	54.77 ± 9.66	0.629
Sex (Male/female)	16/14	18/12	0.602
Body mass index	23.60 (2.72)	24.09 (2.72)	0.492
Vital sign			
SBP	128.03 ± 16.45	134.03 ± 17.91	0.182
MBP	95.74 ± 12.64	101.87 ± 12.37	0.065
RR	25.00 [21.25, 27.00]	25.00 [24.00,26.00]	0.412
HR	89.60 ± 14.58	95.30 ± 16.20	0.157
Symptoms			
Cough (%)	16 (53.3%)	16 (53.3%)	1.000
Sputum (%)	6 (20.0%)	5 (16.7%)	0.739
Fever (%)	26 (86.7%)	22 (73.3%)	0.197
Dyspnea (%)	16 (53.3%)	12 (40.0%)	0.301
Past history (%)	12 (40.0%)	13 (43.3%)	0.793
Hypertension (%)	9 (30%)	6 (20.0%)	0.371
Coronary heart disease	1 (3.3%)	2 (6.7%)	1.000
Diabetes Meletus	3 (10.0%)	4 (13.3%)	1.000
Stoke	0 (0%)	1 (3.3%)	1.000
Oxygen therapy			
Nasal Cannula oxygen	19 (63.3%)	20 (66.7%)	0.136
Mask oxygenation	7 (23.3%)	10 (33.3%)	0.136
High-Flow Nasal Cannula	4 (13.3%)	0 (0.0%)	0.136
Treatment			
Glucocorticoids use (%)	1 (3.3%)	3 (10.0%)	0.605
Lopinavir/Ritonavir (%)	30 (100%)	30 (100%)	
Respiratory support (%)	30 (100%)	30 (100%)	
MMT	4.00 [4.00, 5.00]	3.50 [3.00, 5.00]	0.077
ADL	85.00 [80.00, 90.00]	75.00 [66.25, 90.00]	0.152
Data are reported as the mean ± standard deviation, or median (25th centile, 75th centile), or N(%), unless stated otherwise. Abbreviations: mMRC= Modified British Medical Research Council; MMT= manual muscle test; ALD= activities of daily living scores.			

Table 2. Variable of arterial blood gas analysis between two groups before discharge

Variables	Control group(N = 30)		PR group(N = 30)		Inter-group difference p value			
	Baseline	Before discharge	Intra-group p value	Baseline	Before discharge	Intra-group p value	At baseline	Before discharge
SpO ₂	91.00 [89.75,94.00]	97.00 [97.00,98.00]	0.000	92.20 ± 2.62	98.00 [97.25, 99.00]	0.000	0.371	0.000
PaO ₂	61.00 [56.50, 68.00]	80.23 ± 6.50	0.000	65.50[61.00,70.00]	90.47 ± 7.82	0.003	0.099	0.038
PaCO ₂	43.00 [41.50, 44.50]	41.26 [38.82, 43.75]	0.003	42.50 [40.25, 46.00]	40.33 [38.44, 42.75]	0.003	0.063	0.364
BE	4.27 [4.02,4.89]	3.20 [3.10, 3.30]	0.000	4.25 [3.08,5.73]	3.00 [2.50,3.58]	0.000	0.885	0.576

Data are reported as mean ±SD or Inter-Quartile Range. RR=respiratory rate; SpO₂= Percutaneous oxygen saturation; PaO₂= partial pressure of oxygen; PaCO₂=arterial partial pressure of carbon dioxide; BE=buffer excess.

Figures

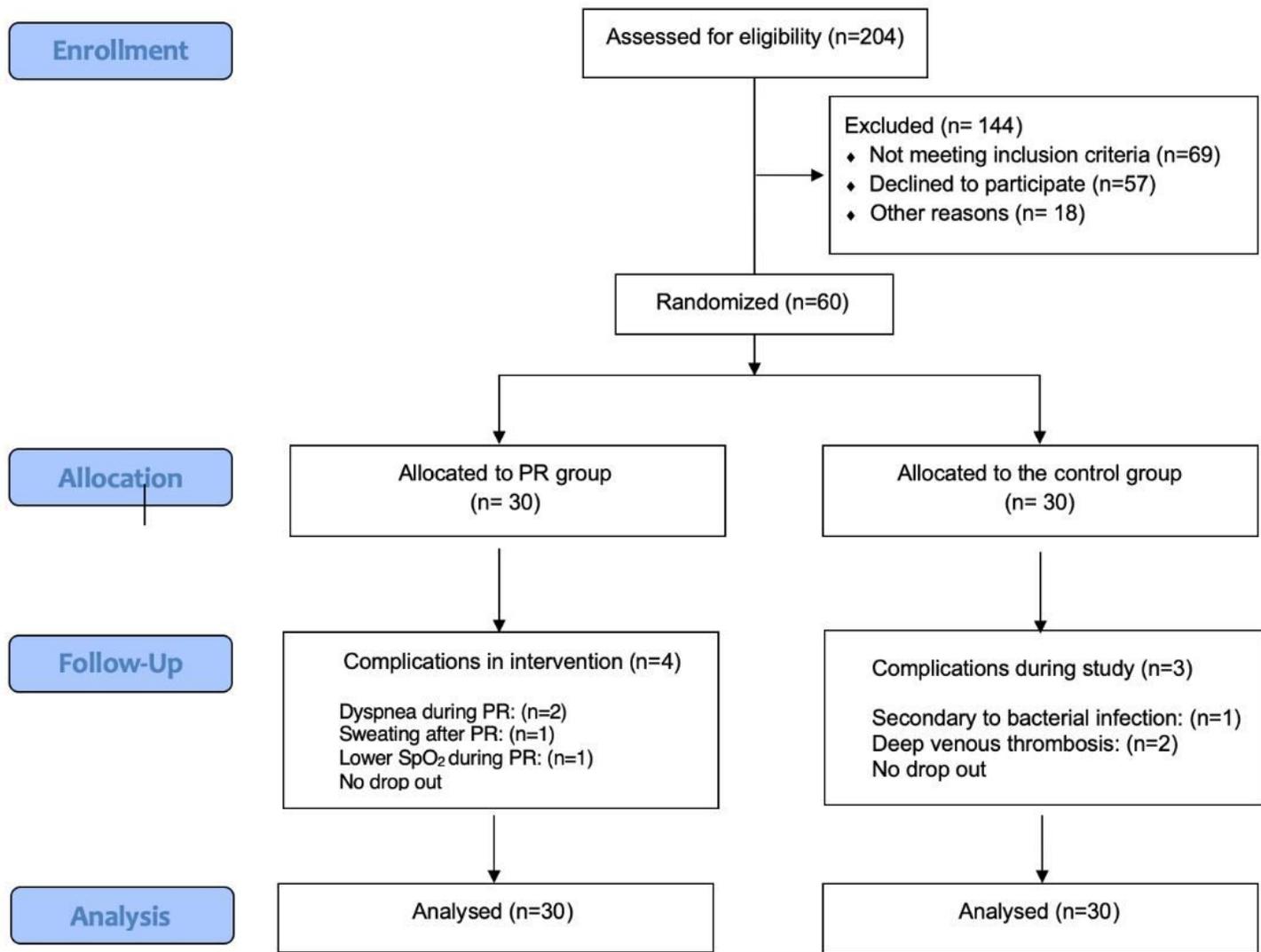


Figure 1

Study flowchart. Flow diagram illustrating the number of participants in each group.

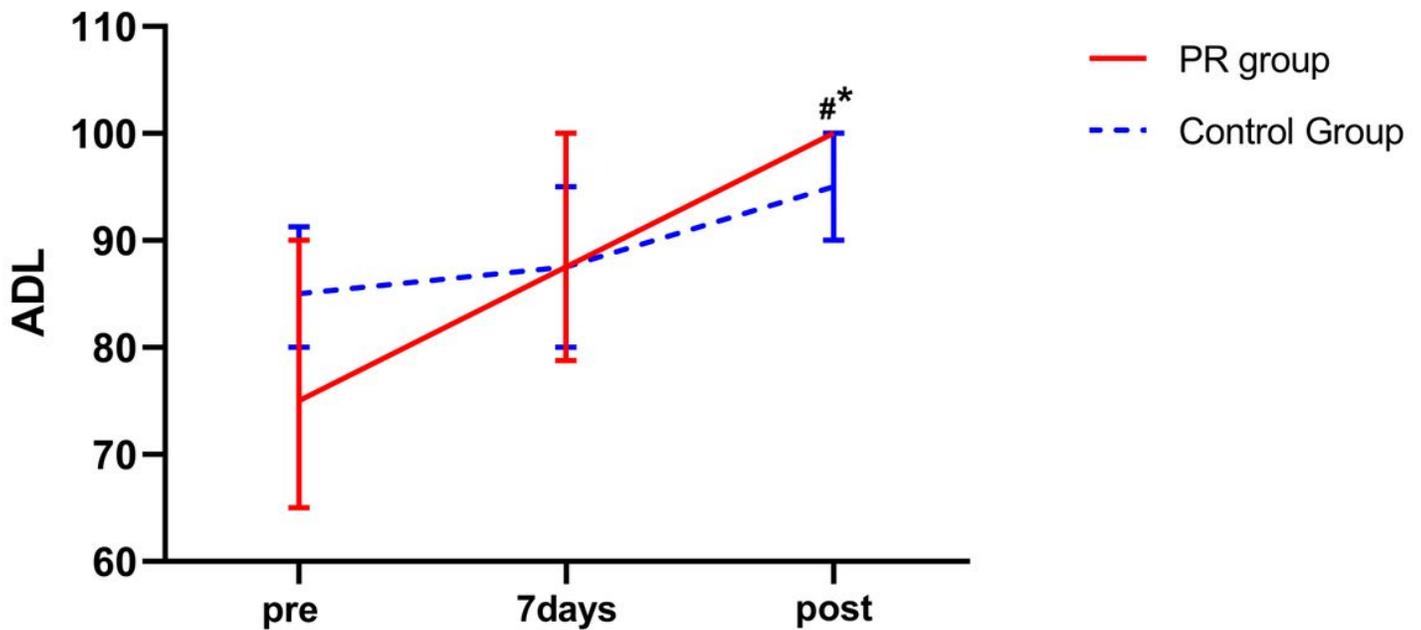


Figure 2

Mean values of ADL before pulmonary rehabilitation (pre), after seven days of exercise (one week) and before discharge (post) the in pulmonary rehabilitation group patients and in control group. * Intra-group analysis following intervention before discharge ($p < 0.001$). # Comparisons of changes in post minus pre intervention between groups showed greater improvement in PR group ($p < 0.001$).

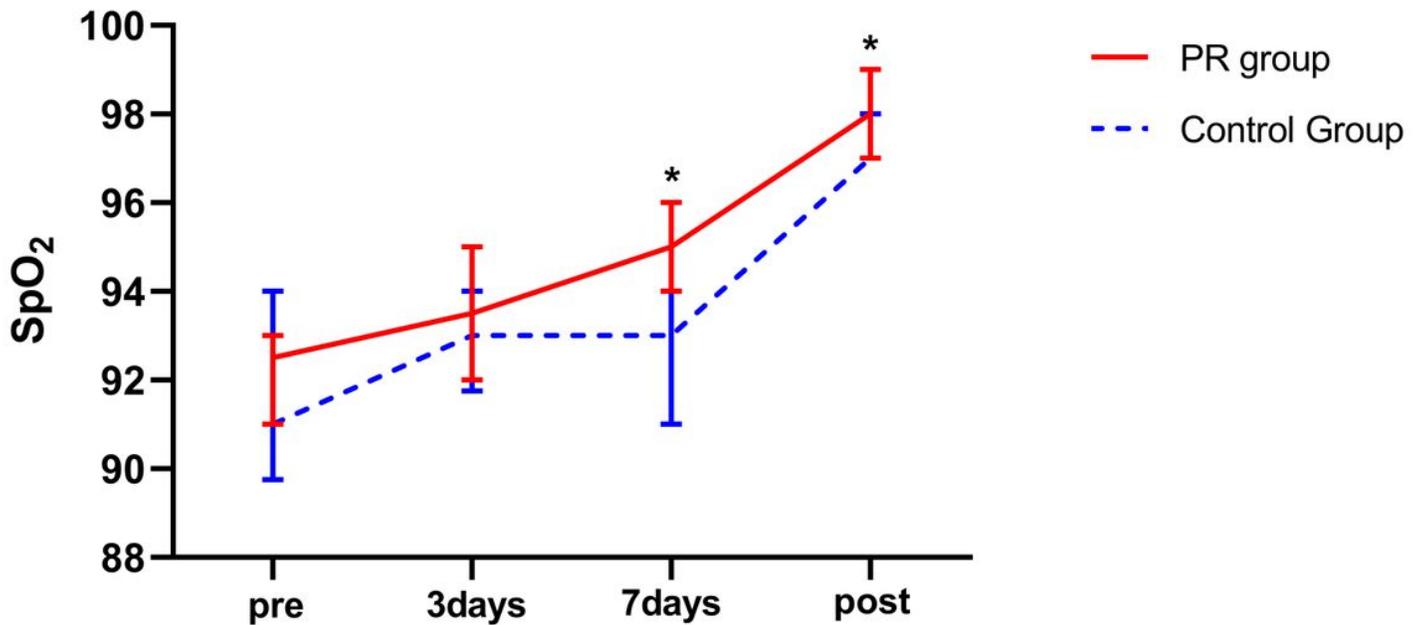


Figure 3

Mean values of SpO₂ before pulmonary rehabilitation (pre), after three days (3days) and seven days of exercise (7 days) and before discharge (post) the in pulmonary rehabilitation group patients and in control group. * Inter-group analysis following

intervention before discharge($p < 0.001$).

Supplementary Files

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- [Supplementarymaterial.docx](#)