ORIGINAL ARTICLE

Pulmonary Daoyin as a traditional Chinese medicine rehabilitation programme for patients with IPF: A randomized controlled trial

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ABSTRACT

Background and objective: IPF is a chronic progressive lung disease in which PR provides benefit for patients. PD, a TCM PR programme, has known effectiveness in COPD, but its utility in IPF is unknown. We investigated its effectiveness and safety in patients with IPF.
Methods: A 6-month randomized controlled trial (RCT) was conducted in three Chinese clinics. Ninety-six participants diagnosed with IPF were randomly assigned to one of the three groups: the PD group received a PD programme two times a day, 5 days/week for 2 months, and the exercise group exercised via a stationary cycle ergometer, 30 min/day, 5 days/week for 2 months. Volunteers in the control group were advised to maintain their usual activities. Primary outcomes were changes from baseline in the 6MWD and HRQoL score on the SGRQ-I at 1 and 2 months (at the end of the intervention) and at 6 months (4 months after the intervention). Secondary outcomes measures included FVC, DL_{CO} (% predicted) and the changes in mMRC.
Results: The 6MWD was increased in the PD group compared to exercise and control groups. 6MWD increased by 60.44 m in the PD group, 32.16 m in the exercise group and 12.42 m in controls after the 2 months of rehabilitation programme. The between-group differences in the change from baseline were

28.78 m (95% CI: 0.54 to 56.01; *P* = 0.044) and 48.02 m (95% CI: 23.04 to 73.00; *P* < 0.001) at 2 months, and 25.61 m (95% CI: −0.67 to 51.89; *P* = 0.058) and 50.93 m (95% CI: 25.47 to 76.40; *P* < 0.001) at 6 months, respectively, including a difference exceeding the MCID. There was no significant change in the SGRQ-I score, the mMRC dyspnoea score, FVC and DL_{CO} (% predicted) in either the PD or exercise groups.
Conclusion: Two months after the intervention, a clinically meaningful difference in 6MWD was observed favouring the PD programme. The PD programme is safe and effective as a rehabilitation intervention designed to increase exercise tolerance and is an appropriate substitute for PR.

SUMMARY AT A GLANCE

This is a randomized clinical trial evaluating the effects of PD, a TCM PR programme, in patients with IPF. PD was associated with a clinically meaningful difference in the 6MWD.

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INTRODUCTION

Idiopathic pulmonary fibrosis (IPF) is a chronic disease with variable natural history in which progressive deterioration in lung function occurs, resulting in significant morbidity and mortality. Median survival is 2–3 years.[1] The incidence is 2–30 cases per 100 000 person-years and the prevalence ranges from 10 to 60 cases per 100 000 people[2–6] depending upon the country surveyed. These figures roughly translate to a population prevalence of 130 000 in the United States,

300 000 in Europe, 640 000 in East Asia and ~3 million people worldwide.[7] In patients aged >65 years, the estimated prevalence of IPF is as high as 400 cases per 100 000 people in the United States.[8] There is a paucity of prevalence data from China, but the current data indicate that the incidence of IPF is increasing. Increasing rates of hospital admissions and deaths due to IPF also suggest an increasing burden of disease.[9]

During the past 5 years, notable advances have been made in pharmacotherapeutic management of IPF, with the introduction of nintedanib and pirfenidone. Both are safe and effective in the treatment of IPF patients.[10,11] However, the lack of prolonged survival time and their high costs limit their global clinical application. Non-pharmacological management strategies reduce morbidity, and the importance of these approaches cannot be overemphasized.[9] Supplemental oxygen and pulmonary rehabilitation (PR) are strongly recommended for patients with IPF in clinical practice guidelines.[11,12] PR, a structured exercise programme designed for adults with advanced lung disease,[9] has been found to improve walking distance, symptoms and quality of life for patients with IPF.[13–15]

Pulmonary Daoyin (PD), a traditional Chinese medicine (TCM) PR technology, was established based on the Daoyin skills.[16] Although the effects of PD for chronic obstructive pulmonary disease (COPD) patients have been reported in a previous study,[17] the effectiveness of the programme in patients with IPF is unknown. The present study investigated the effectiveness and safety of PD compared with usual care in patients with IPF.

METHODS

Study design

This study was a randomized clinical trial. Subjects were randomly assigned to one of the three groups: PD, exercise and control groups. Random allocation was done using randomizer software (SAS 9.4). The trial was registered in the Chinese Clinical Trial Registry (ChiCTR-IOR-17011187) on Apr 19, 2017. Ethical approval was obtained from the Ethical Research Committee of the First Affiliated Hospital of Henan University of Chinese Medicine (batch number is 2016HL-083). Written informed consent was obtained from all participants.

Sample size

The sample size was based on the effect of PR on the 6-min walking distance (6MWD) in IPF. Jackson *et al.*[18] found that PR for 3 months improved the 6MWD of IPF patients (354.4 ± 37.2 vs 324.1 ± 35.5), with a significance level of 5%, a power of 0.90 at a 5% significance level (two-sided), hence 32 subjects per group were required.

Study subjects

Subjects were diagnosed with IPF according to the diagnosis of IPF (an official American Thoracic Society/European Respiratory Society/Japanese Respiratory Society/Latin American Thoracic Association (ATS/ERS/JRS/ALAT) Clinical Practice guideline).[11]

The inclusion criteria included stable IPF and age between 40 and 85 years. Exclusion criteria were resting oxygen saturation < 90%, cognitive impairment/mental illness, post-exercise syncope, osteoarthritis and severe comorbidities, including acute myocardial infarction and unstable angina pectoris.

Intervention protocol

PD group

PD, a TCM PR technology, was established based on the Daoyin skills and TCM theory for patients with COPD.[16] It is a gentle meditative technique that applies physical movements, breathing exercises and mind regulation. It is based on the principle of integrating and harmonizing one's mind, breath, posture and movement, including respiratory muscle training. The detailed steps and the pictorial posture description of the PD programme may be found in the study protocol that has been published by our team.[16]

Subjects in the PD group completed a 2-month PD programme, which consisted of two stages. The first stage is a 1-month intensive exercise phase. At this stage, subjects exercised 5 days a week. They were allowed to split the 1-h exercise time into morning and afternoon sessions. The PD class was led by a qualified PD instructor. The PD techniques were re-assessed at the 1-month time point to ensure that proper skills were maintained. The second stage was a 1-month unsupervised exercise phase at home 5 days a week, two times a day. Along with written instructions, a CD was also given to each subject to facilitate daily self-practice. A diary was also provided to each subject for recording the frequency of their sessions.

Exercise group

The exercise training was a general programme (not specific for IPF) which involved a five times-a-week outpatient programme of exercise training integrated with peripheral muscle training. Before starting an exercise training programme, blood pressure, oxygen saturation and heart rate were measured to assess potential oxygenation needs and help ensure the safety of the intervention. The target heart rate and the exercise intensity were determined according to the 6-min walk test results. The exercise programme consisted of 5 minutes of warming up the subject's muscles and cardiovascular system prior to exercise training on a stationary cycle ergometer. After reaching target heart rate, training was continued at this intensity for 20 min. Blood pressure, oxygen saturation and heart rate were measured again after exercise. Lastly, relaxation training was undertaken for 10 min. Supplemental oxygen was given to maintain oxygen saturation above 90% if desaturation was observed. Subjects in the exercise group completed a 2-month exercise programme.

Control group

Subjects in the control group were advised to maintain their usual activities. No extra exercise was recommended.

Assessment

The primary outcomes were 6MWD and the St George's Respiratory Questionnaire for IPF (SGRQ-I). The 6MWD was carried out according to the ATS criteria.[19] The SGRQ-I is a useful tool to measure health-related quality of life (HRQoL) in patients with IPF that can be utilized in patients with different disease durations.[20] It evaluates the impact of respiratory disease based on three domains: symptoms, activity and psychosocial impact, as well as providing an overall score. The higher the score, the more severe the individual's burden of IPF.

The secondary outcomes were forced vital capacity (FVC), diffusing capacity of the lung for carbon monoxide (DL_{CO}) and the modified British Medical Research Council (mMRC) breathlessness scale. Lung function, FVC and DL_{CO} correlate with IPF disease outcomes, with more advanced impairments associated with decreased HRQoL[21] and survival.[22] The mMRC scale is a self-rating tool to measure the degree of disability that breathlessness poses on day-to-day activities on a scale from 0 (no breathlessness except on strenuous exercise) to 4 (too breathless to leave the house, or breathless when dressing or undressing).[23,24] An increasing mMRC score reflects impaired HRQoL and a high symptom burden. It has been used as a simple screening tool for the palliative care needs of IPF patients[25] and one of the indicators of efficacy evaluation in clinical trials related to IPF.[26]

Data collection of 6MWD, SGRQ-I and mMRC was performed at baseline, months 1 and 2 (the end of the intervention) and month 6 (4 months after the intervention). The primary outcomes were changes from baseline in 6MWD and SGRQ-I after 1 and 2 months of the intervention and 6 months. Results of FVC and DL_{CO} were recorded at baseline and at month 2.

Statistical analysis

Data analyses were conducted using SAS 9.2 software (SAS Institute Inc., Cary, NC, USA). Descriptive statistics were used to define the demographic characteristics of the sample. One-way analysis of variance (ANOVA) was used to compare group means. Paired t-tests (with 95% CI) were used to examine within-group changes from baseline to 1, 2 and 6 months. A *P*-value of 0.05 (two-sided) was taken as the level of significance. To preserve the value of randomization, we used the intention-to-treat (ITT) analysis. Missing data of withdrawn participants were replaced with the last-observation-carried-forward method.

RESULTS

Participants and baseline characteristics

From April 2017 to August 2018, a total of 169 patients were recruited (83 were recruited from the Third Affiliated Hospital of Henan University of Chinese Medicine, 41 from the Ruzhou Hospital of Chinese Medicine and 45 from the Affiliated Hospital of Changchun University of Chinese Medicine) from the outpatients department and screened for eligibility. A total of 96 subjects were randomly assigned to each of the following groups: the PD group (*n* = 32), exercise group (*n* = 31) and control group (*n* = 33). A total of 92 patients (95.8%) received 2 months of rehabilitation; 89 patients (92.7%) completed the study. All randomized patients were included in the ITT population (Fig. 1). The demographic and baseline characteristics are shown in Table 1. There were no significant differences in clinically relevant baseline characteristics among the three groups.
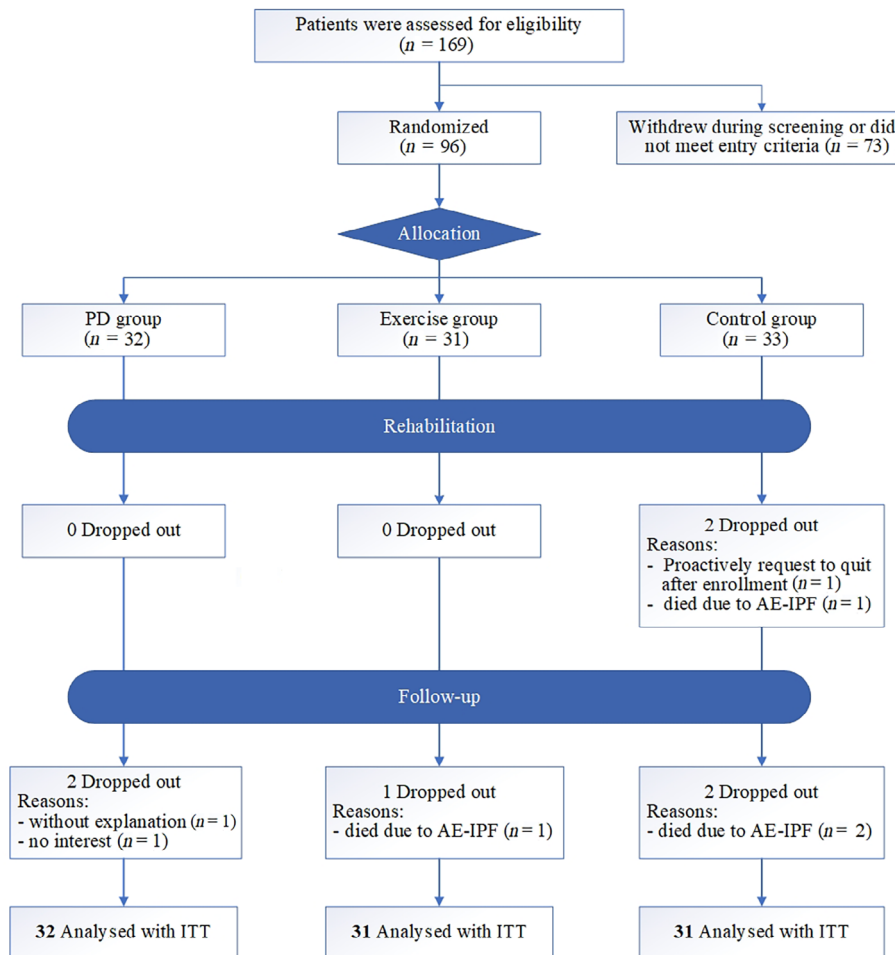
Primary outcomes

As shown in Figure 2A, the 6MWD was improved at 1 and 2 months compared with baseline in the three groups and decreased after 4 months of follow-up compared with the intervention. There were statistical differences between the baseline changes in 6MWD after 1 and 2 months and 6 months among the three groups. Principal outcomes are shown in Table 2. The 6MWD was increased in the PD group compared to the exercise and control groups (between-group difference in the change from baseline: 15.33 m; 95% CI: −3.88 to 34.53; *P* = 0.154 and 21.33 m; 95% CI: 3.80 to 38.86; *P* < 0.013 at 1 month and 28.78 m; 95% CI: 0.54 to 56.01; *P* = 0.044 and 48.02 m; 95% CI: 23.04 to 73.00; *P* < 0.001 at 2 months and 25.61 m; 95% CI: −0.67 to 51.89; *P* = 0.058 and 50.93 m; 95% CI: 25.47 to 76.40; *P* < 0.001 at 6 months, respectively). The difference between exercise and control groups in mean change from baseline for 6MWD at 1 month was 6.00 (95% CI: −6.92 to 18.92; *P* = 0.586), at 2 months was 19.74 (95% CI: 1.43 to 38.06; *P* = 0.031) and at 6 months was 25.32 (95% CI: 1.62 to 49.02; *P* = 0.033).

As shown in Figure 3, symptoms, activity, impact and SGRQ-I total scores were decreased at 1 and 2 months compared with baseline in the three groups and increased after 4 months of follow-up compared to the end of the intervention. There were statistical differences between the changes from baseline activity, impact and SGRQ-I total score after 2 months among the three groups.

No differences were observed for the symptoms and changes from baseline after 1 and 6 months for all domains of the SGRQ-I (Table 2). The between-group difference in mean change from baseline for PD and control groups for the SGRQ-I total score was −13.56 (95% CI: −23.64 to −3.47; *P* = 0.005) at 2 months and −13.36 (95% CI: −26.93 to 0.20; *P* = 0.055) at 6 months; for impact, it was −15.70 (95% CI: −28.30 to −3.11; *P* = 0.010) and −16.69 (95% CI: −32.54 to −0.85; *P* = 0.036), respectively; for activity, it was −13.90 (95% CI: −24.61 to 5.58; *P* = 0.007) at 2 months.

Secondary outcomes

As shown in Figure 2C, the mMRC score was decreased at 1 and 2 months compared to baseline in the three groups and increased after 4 months of follow-up compared to the end of the intervention. There were statistical differences in the changes from baseline in the mMRC score after 2 and 6 months among the three groups. No differences were observed for changes from baseline after 1 month (Table 2). The between-group difference in mean change from baseline for PD and control for the mMRC score was −0.40 (95% CI: −0.71

Figure 1 Study flow chart to track participants through randomized controlled trial. AE-IPF, acute exacerbation of idiopathic pulmonary fibrosis; ITT, intention-to-treat; PD, pulmonary Daoyin.

PD, Pulmonary Daoyin; AE-IPF, acute exacerbation of IPF; ITT, intention to treat.

to −0.10; P = 0.005) at 2 months and −0.47 (95% CI: −0.85 to −0.08; P = 0.013) at 6 months; for exercise and control, it was −0.32 (95% CI: −0.60 to 0.04; P = 0.020) at 2 months. Other differences were not observed.

As can be seen in Figure 2E,G, changes in FVC and DL_{CO} (% predicted) occurred. The difference between PD and the control group in mean change from baseline of FVC at 2 months was 0.25 (95% CI: 0.04 to 0.46; P = 0.016), and it was 4.19 for DL_{CO} (% predicted) (95% CI: −0.37 to 8.76; P = 0.080). No differences were observed for FVC and DL_{CO} (% predicted) between PD and exercise, or exercise and control groups (Table 2). Pairwise comparisons for FVC and DL_{CO} (% predicted) among the three groups at 2 months indicated a significant difference between the PD and the control groups (P = 0.046 and 0.006, respectively; Table 3).

The 6MWD, mMRC, FVC and DL_{CO} (% predicted) changes from 1, 2 and 6 months from baseline are shown in Figure 2B,D,F,H.

Safety

A total of 10 patients (1 in the PD group, 3 in the exercise group and 6 in the control group) reported adverse events (AE). Among these, six AE were reported as mild or moderate, including two patients who had hypertension, one patient who had knee pain, one patient who had chest tightness, one patient who had a cold and one patient who experienced an acute exacerbation of IPF (AE-IPF). All patients recovered completely from the AE after treatment or discontinuation of training and remained in the trial. Four patients (one subject in the exercise group and three subjects in the control group) experienced severe AE. They died due to AE-IPF.

DISCUSSION

To our knowledge, our study is the first to explore the effect of a TCM PR programme on the treatment of IPF. We found that a PD programme for 2 months, as compared with the exercise group and the control group, exceeded the minimal clinically important difference (MCID) of 28 m with a range of 10.8–58.5 m[27] or 25–45 m[28] 6MWD for IPF patients. No significant changes occurred in total SGRQ-I score, mMRC score or spirometry in any of the groups. We concluded that

Table 1 Demographic and clinical characteristics of the study participants at baseline

	Control group ($n = 31$)	Exercise group ($n = 31$)	PD group ($n = 32$)	ANOVA *P*-value
Age, years, mean (SD)	67 ± 10	64 ± 9	66 ± 11	0.497
Gender				0.965
Male (%)	17 (54.84)	18 (58.06)	19 (59.38)	
Female (%)	14 (45.16)	13 (41.94)	13 (40.62)	
Height, cm, mean (SD)	168.19 ± 6.99	167.33 ± 6.28	167.22 ± 6.17	0.811
Weight, kg, mean (SD)	67.19 ± 12.53	65.85 ± 13.30	65.97 ± 9.27	0.884
Co-existing diseases				0.269
Hypertension (%)	4 (12.90)	4 (12.90)	2 (6.25)	
Coronary heart disease (%)	3 (9.68)	0	1 (3.125)	
Diabetes (%)	1 (3.23)	0	2 (6.25)	
Allergic rhinitis (%)	0	0	1 (3.125)	
Prostate hyperplasia (%)	0	0	1 (3.125)	
mMRC, mean (SD)	2.77 ± 0.99	2.77 ± 1.15	2.81 ± 1.12	0.987
6MWD, mean m (SD)	281.52 ± 106.84	279.10 ± 108.08	284.06 ± 129.20	0.986
FVC, L, mean (SD)	2.12 ± 0.49	2.25 ± 0.70	2.17 ± 0.49	0.667
FEV_1, L, mean (SD)	1.54 ± 0.48	1.67 ± 0.57	1.54 ± 0.46	0.478
DL_{CO} (% predicted)	62.43 ± 7.80	65.17 ± 14.60	65.47 ± 9.79	0.492
BBS, mean (SD)	42.73 ± 13.78	45.17 ± 9.17	42.43 ± 14.69	0.663
SGRQ-I (Symptoms)	84.84 ± 15.20	84.56 ± 15.13	84.93 ± 18.96	0.996
SGRQ-I (Activity)	80.05 ± 26.27	79.43 ± 20.69	80.36 ± 21.83	0.987
SGRQ-I (Impact)	76.37 ± 28.42	76.22 ± 23.17	74.98 ± 26.87	0.974
SGRQ-I (Total)	78.94 ± 24.83	78.66 ± 19.39	78.39 ± 23.06	0.995

6MWD, 6-min walking distance; ANOVA, analysis of variance; BBS, Berg Balance Scale; DL_{CO}, diffusing capacity of the lung for carbon monoxide; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; IPF, idiopathic pulmonary fibrosis; mMRC, modified British Medical Research Council; PD, pulmonary Daoyin; SGRQ-I, St George's Respiratory Questionnaire for IPF.

PD and exercise are non-inferior to PR, and PD may increase exercise tolerance.

The findings of the current study demonstrate that the PD programme was more effective than the control group or the exercise group in increasing 6MWD. Our findings are consistent with those of previous meta-analyses[29–31] that examined the effectiveness of PR across multiple studies which show that PR increases exercise tolerance in patients with IPF. PR is a comprehensive intervention designed to improve the physical and psychological condition of the patient and promote long-term adherence to health-enhancing behaviours.[32] The primary purpose is to alleviate the symptoms of dyspnoea, improve respiratory function, improve exercise tolerance, improve the ability to participate in social activities and daily life activities, reduce the frequency of hospitalization and medical expenses, and improve the overall quality of life. The ATS/ERS/JRS/ALAT 2015 IPF guideline[10] and the Japanese guideline for treating IPF[12] suggest that patients with IPF in the chronic phase should be treated with PR.

The 6MWD is a useful measure of functional capacity targeted at people with at least moderately severe impairment.[19] It is helpful in assessing disease stage severity, provides information on therapeutic outcomes and predicts morbidity and mortality in patients with IPF.[28,33,34] The SGRQ total score is one of the independent prognostic factors in patients with IPF.[35] The SGRQ-I is a useful measure of HRQoL in patients with IPF.[36] PR has been found to improve walking distance and HRQoL for patients with IPF.

In our study, 6MWD increased by 60.44 m in the PD group, 32.16 m in the exercise group and 12.42 m in controls after the 2-month rehabilitation programme. The significance of our findings depends on the MCID of the parameters measured. The difference between PD and exercise groups in mean change from baseline for 6MWD at 2 months exceeded the MCID of 28 m with a range of 10.8–58.5 m[27] or 25–45 m[28] 6MWD for IPF patients. Four months after the end of the intervention, the difference between PD and exercise groups in mean change from baseline for 6MWD was 25.61 m (95% CI: −0.67 to 51.89; $P = 0.058$). Although not statistically different, the difference in 6MWD between the two groups was 25.61 m which is classified as an MCID (25–45 m), and no rehabilitation training was performed during the 4-month follow-up period. The between-group difference in mean change from baseline for PD and exercise for the SGRQ-I total score at 2 and 6 months exceeded the MCID (5–8 points),[37] but there was no significant differences between the groups. A meta-analysis of seven randomized controlled trial (RCT) involving 190 patients[29] concluded that PR has a positive effect on 6MWD of 48.60 m (95% CI: 29.03 to 68.18), and the SGRQ-I total score was lower (−7.87; 95% CI: −11.44 to −4.30). Another study observed a mean reduction of 9.1 in the total score of SGRQ-I for IPF patients after rehabilitation for 3 months and an increase of 15.5 in the control group.[38]

Dyspnoea is a common symptom experienced by IPF patients and typically progresses over months to years.
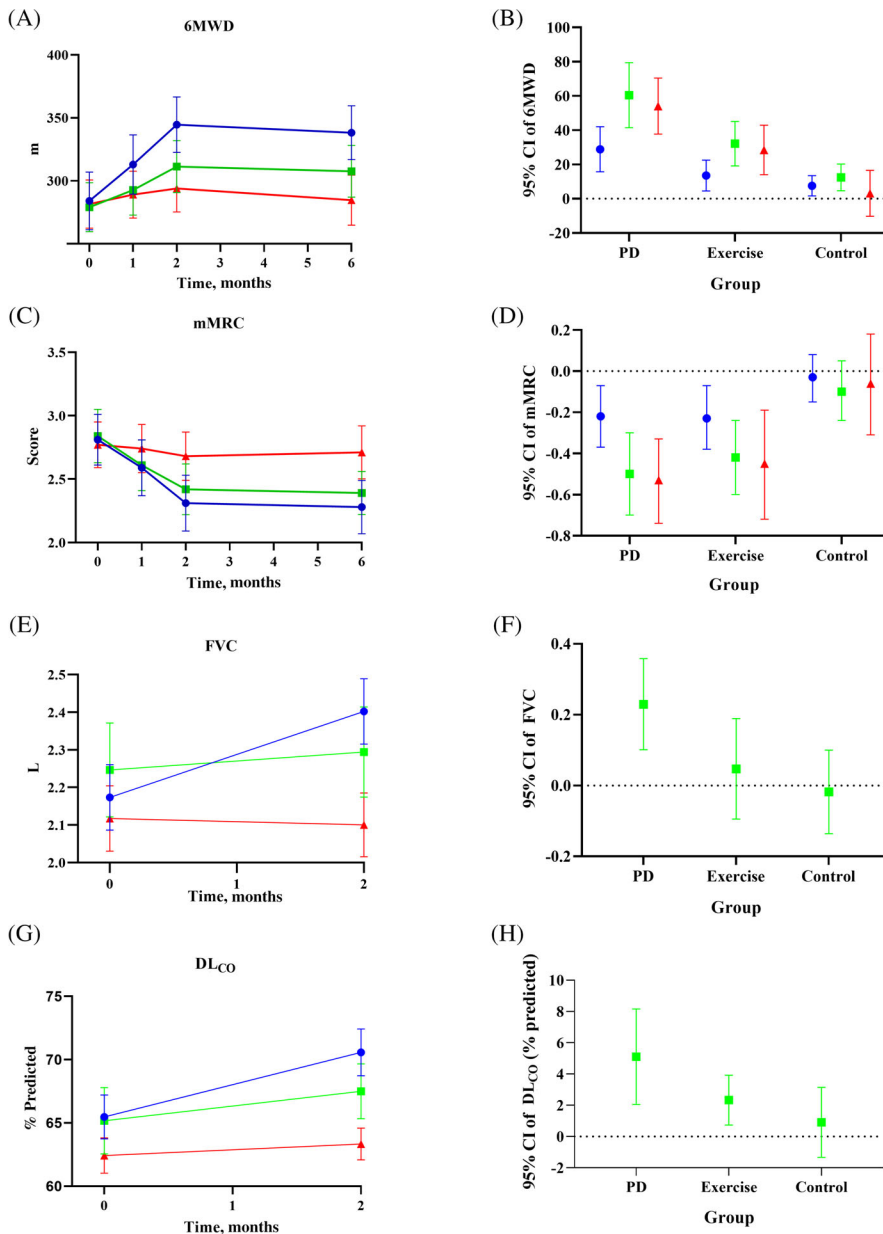
Figure 2 6MWD, mMRC, FVC and DL$_{CO}$ (% predicted) outcomes over time and changes from baseline during the study. Results of the 6MWD, mMRC, FVC and DL$_{CO}$ (% predicted) over time during the study (A, C, E and G), and changes from baseline in the 6MWD, mMRC, FVC and DL$_{CO}$ (% predicted) of the study groups (B, D, F and H). (A, C, E and G) ●, PD; ■, exercise; ▲, control. (B, D) ●, $T_1 - T_0$; ■, $T_2 - T_0$; ▲, $T_6 - T_0$. (F, H) ■, $T_2 - T_0$. 6MWD, 6-min walking distance; DL$_{CO}$, diffusing capacity of the lung for carbon monoxide; FVC, forced vital capacity; mMRC, modified British Medical Research Council; PD, pulmonary Daoyin; $T_1 - T_0$, changes at the first month study endpoint from baseline; $T_2 - T_0$, changes at the end of the rehabilitation study endpoint from baseline. $T_6 - T_0$, changes at the end of the follow-up study endpoint from baseline.

Reducing dyspnoea is an aim of PR. The mMRC reflects breathlessness in patients with IPF, and it could be used as a simple screening tool for efficacy assessment.[25] The MCID of the mMRC dyspnoea score, FVC and DL$_{CO}$ (% predicted) in patients with IPF have not been described as far as we know. The difference between PD and exercise groups in mean change from baseline in mMRC dyspnoea score at 2 and 6 months was not statistically different. The equivalence of mMRC dyspnoea score in the PD and exercise groups at the end of the intervention might be related to both increasing quadriceps strength.[39]

Spirometry is widely performed in the diagnosis, classification, treatment and monitoring of IPF patients.[16] FVC and DL$_{CO}$ (% predicted) are typical parameters used in clinical research. Surprisingly, in our study, we found a significant increase in FVC and DL$_{CO}$ at 2 months in the PD group only. Previous studies have found, for example, reduced DL$_{CO}$ (% predicted) of 2 for the exercise training programme and 4 for the control group after 11 months.[14] The changes observed could be related to assessing changes over a relatively short period (2 months), a small sample size or the baseline health status of the patients. It is possible that the baseline health care of patients entering our study is lower that would be typically observed in clinical trials of IPF. It is also possible that as PD is designed to improve psychological outcomes, patients in this group were more motivated to perform better in these tests. Interestingly, there is a known relationship between depression and reduced lung function measurements,[40] and while we were unable to find comparable studies in patients with IPF, in patients with COPD who were treated for depression there were improvements in spirometry measurements.[41]

Table 2 Between-group differences in the change from baseline

Measure	Control (n = 31)	Exercise (n = 31)	PD (n = 32)	P-value	Difference between groups in change from baseline					
					PD vs exercise 95% CI	P-value	PD vs control 95% CI	P-value	Exercise vs control 95% CI	P-value
6MWD (m)										
$T_1 - T_0$	7.55 ± 16.00	13.55 ± 24.42	28.88 ± 36.51	0.007	15.33 (−3.88 to 34.53)	0.154	21.33 (3.80 to 38.86)	0.013	6.00 (−6.92 to 18.92)	0.586
$T_2 - T_0$	12.42 ± 21.20	32.16 ± 35.45	60.44 ± 52.63	0.001	28.78 (0.54 to 56.01)	0.044	48.02 (23.04 to 73.00)	0.001	19.74 (1.43 to 38.06)	0.031
$T_6 - T_0$	3.16 ± 36.54	28.48 ± 39.45	54.09 ± 45.45	0.001	25.61 (−0.67 to 51.89)	0.058	50.93 (25.47 to 76.40)	0.001	25.32 (1.62 to 49.02)	0.033
SGRQ-I (Symptoms)										
$T_1 - T_0$	−1.24 ± 8.22	−1.83 ± 5.77	−3.90 ± 7.35	0.309	−2.07 (−6.15 to 2.01)	0.519	−2.66 (−7.49 to 2.17)	0.448	−0.59 (−5.03 to 3.85)	0.983
$T_2 - T_0$	−1.82 ± 7.73	−3.77 ± 8.16	−8.13 ± 17.19	0.105	−4.35 (−12.71 to 4.00)	0.490	−6.31 (−14.59 to 1.98)	0.182	−1.96 (−6.91 to 3.00)	0.704
$T_6 - T_0$	−1.08 ± 12.69	−2.18 ± 14.03	−7.03 ± 19.80	0.288	−4.85 (−15.45 to 5.75)	0.599	−5.95 (−16.23 to 4.33)	0.403	−1.10 (−9.44 to 7.24)	0.983
SGRQ-I (Activity)										
$T_1 - T_0$	−2.58 ± 8.51	−4.74 ± 15.14	−7.12 ± 10.46	0.310	−2.38 (−10.48 to 5.72)	0.850	−4.54 (−10.43 to 1.35)	0.177	−2.16 (−9.87 to 5.55)	0.866
$T_2 - T_0$	−4.52 ± 13.95	−11.16 ± 23.75	−18.42 ± 20.15	0.023	−7.26 (−20.90 to 6.38)	0.477	−13.90 (−24.61 to 5.58)	0.007	−6.64 (−18.86 to 5.58)	0.455
$T_6 - T_0$	−3.39 ± 29.56	−7.68 ± 24.47	−15.52 ± 17.49	0.138	−7.83 (−21.06 to 5.39)	0.384	−12.13 (−27.30 to 3.04)	0.152	−4.30 (−21.23 to 12.63)	0.898
SGRQ-I (Impact)										
$T_1 - T_0$	−5.56 ± 10.98	−6.82 ± 17.92	−9.24 ± 13.63	0.591	−2.42 (−12.30 to 7.47)	0.907	−3.68 (−11.33 to 3.96)	0.560	−1.26 (−10.58 to 8.05)	0.982
$T_2 - T_0$	−6.20 ± 19.26	−10.92 ± 24.05	−21.91 ± 21.47	0.015	−10.98 (−25.09 to 3.13)	0.170	−15.70 (−28.30 to −3.11)	0.010	−4.72 (−18.32 to 8.88)	0.777
$T_6 - T_0$	−4.15 ± 27.97	−9.41 ± 30.39	−20.84 ± 22.91	0.050	−11.44 (−28.15 to 5.28)	0.263	−16.69 (−32.54 to −0.85)	0.036	−5.27 (−23.46 to 12.95)	0.858
SGRQ-I (Total)										
$T_1 - T_0$	−3.82 ± 8.27	−5.31 ± 12.96	−7.61 ± 10.03	0.363	−2.30 (−9.49 to 4.89)	0.817	−3.79 (−9.47 to 1.89)	0.284	−1.49 (−8.30 to 5.32)	0.930
$T_2 - T_0$	−4.87 ± 14.06	−9.76 ± 19.26	−18.42 ± 18.31	0.009	−8.66 (−20.28 to 2.96)	0.200	−13.56 (−23.64 to −3.47)	0.005	−4.90 (−15.43 to 5.64)	0.586
$T_6 - T_0$	−3.35 ± 24.63	−7.73 ± 22.28	−16.72 ± 18.64	0.053	−8.99 (−21.72 to 3.74)	0.240	−13.36 (−26.93 to 0.20)	0.055	−4.37 (−19.01 to 10.27)	0.845
mMRC										
$T_1 - T_0$	−0.03 ± 0.31	−0.23 ± 0.43	−0.22 ± 0.42	0.091	0.01 (−0.25 to 0.27)	NA	−0.19 (−0.42 to 0.04)	0.142	−0.19 (−0.43 to 0.04)	0.131
$T_2 - T_0$	−0.10 ± 0.40	−0.42 ± 0.50	−0.50 ± 0.57	0.004	−0.08 (−0.41 to 0.25)	0.908	−0.40 (−0.71 to −0.10)	0.005	−0.32 (−0.60 to 0.04)	0.020
$T_6 - T_0$	−0.06 + 0.68	−0.45 ± 0.73	−0.53 ± 0.57	0.014	−0.08 (−0.48 to 0.32)	0.948	−0.47 (−0.85 to −0.08)	0.013	−0.39 (−0.82 to 0.05)	0.097
FVC (L)										
$T_2 - T_0$	−0.02 ± 0.32	0.05 ± 0.39	0.23 ± 0.36	0.020	0.18 (−0.05 to 0.41)	0.160	0.25 (0.04 to 0.46)	0.016	0.06 (−0.16 to 0.29)	0.853
DL_{CO} (% predicted)										
$T_2 - T_0$	0.91 ± 6.11	2.33 ± 4.35	5.10 ± 8.47	0.040	2.77 (−1.40 to 6.95)	0.285	4.19 (−0.37 to 8.76)	0.080	1.42 (−1.89 to 4.73)	0.646

Measurement time points at baseline (T_0), 1 month (T_1), 2 months (T_2) and 6 months (after 4 months of follow-up, T_6).
6MWD, 6-min walking distance; DL_{CO}, diffusing capacity of the lung for carbon monoxide; FVC, forced vital capacity; IPF, idiopathic pulmonary fibrosis; mMRC, modified British Medical Research Council; NA, not applicable; PD, pulmonary Daoyin; SGRQ-I, the IPF-specific version of the St George's Respiratory Questionnaire; $T_1 - T_0$, changes at the first month study end-point from baseline; $T_2 - T_0$, changes at the end of the rehabilitation study endpoint from baseline; $T_6 - T_0$, changes at the end of the follow-up study endpoint from baseline.
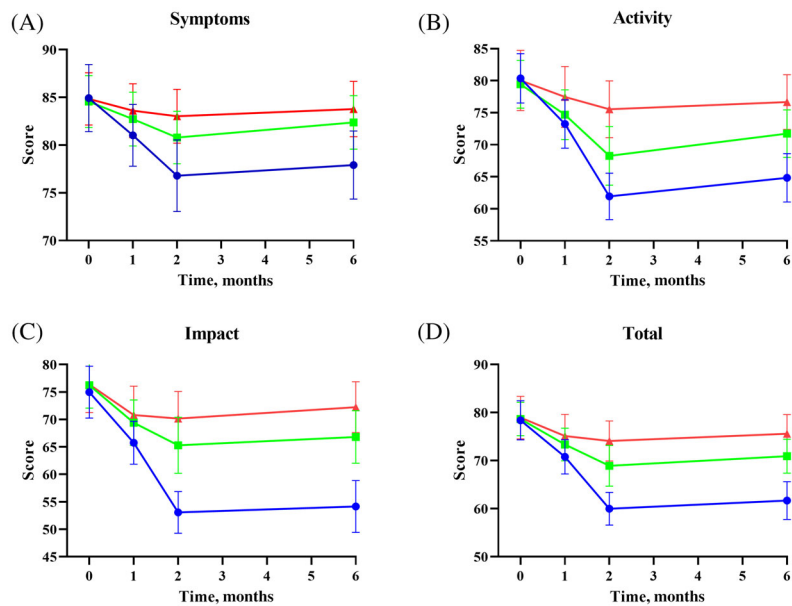
Figure 3 Symptoms, activity, impact and total of SGRQ-I module over time during the study. ●, PD; ■, exercise; ▲, control. PD, pulmonary Daoyin; SGRQ-I, St George's Respiratory Questionnaire for IPF.

6MWD was significantly increased in the PD group in comparison to the exercise group with a magnitude that exceeded the MCID. There were no differences in SGRQ-I score or the mMRC dyspnoea score between the PD and exercise groups. This finding should encourage PD as a substitute for PR because it suggests the effect and the low-cost intervention of the PD programme.

PD may work as an intervention in IPF by the following mechanisms: IPF patients usually show reduced lung compliance and ineffective breathing patterns. In this study, the PD programme combined specially designed movements of the limbs and trunk and controlled breathing exercises. This is designed to effectively expand the chest and stretch the pectoral muscle which may improve breathing efficiency and muscle strength. Less likely but feasible options are that PD enhances pleural elasticity, improves pulmonary ventilation capacity and increases pulmonary ventilation volume.

Our study has some limitations. First, the duration was short. We observed some trends in our data which may have been significantly different if the study duration was longer. Second, despite the uniform training for the PD group participants, it was noted that each patient has a different level of proficiency, which may impact the individual effectiveness of PD. This study population was not treated with either of the anti-fibrotic drugs pirfenidone and nintedanib. Therefore, the combined effects of anti-fibrotic and PD need to be evaluated in other future studies.

In conclusion, a clinically meaningful difference for 6MWD was observed following 2 months of PD. The study results suggest that the PD programme appears to be an appropriate alternative for PR in treating IPF.

Table 3 Pairwise comparisons for FVC and DL_{CO} among the three groups at the second month

Outcome variable	Group	Group	*P*-value	95% CI for difference
FVC	PD	Exercise	0.845	−0.256 to 0.473
		Control	0.046	0.004 to 0.601
	Exercise	PD	0.845	−0.473 to 0.256
		Control	0.469	−0.168 to 0.556
DL_{CO} (% predicted)	PD	Exercise	0.631	−3.923 to 10.071
		Control	0.006	1.727 to 12.754
	Exercise	PD	0.631	−10.071 to 3.923
		Control	0.273	−2.008 to 10.341

DL_{CO}, diffusing capacity of the lung for carbon monoxide; FVC, forced vital capacity; PD, pulmonary Daoyin.

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Abbreviations: 6MWD, 6-min walking distance; AE, adverse event; AE-IPF, acute exacerbation of IPF; ANOVA, analysis of variance; ATS/ERS/JRS/ALAT, American Thoracic Society/European Respiratory Society/Japanese Respiratory Society/Latin American Thoracic Association; COPD, chronic obstructive pulmonary disease; DL_{CO}, diffusing capacity of the lung for carbon monoxide; FVC, forced vital capacity; HRQoL, health-related quality of life; IPF, idiopathic pulmonary fibrosis; ITT, intention-to-treat; MCID, minimal clinically important difference; mMRC, modified British Medical Research Council; PD, pulmonary Daoyin; PR, pulmonary rehabilitation; RCT, randomized controlled trial; SGRQ-I, St George's Respiratory Questionnaire for IPF; $T_1 - T_0$, changes at the first month study endpoint from baseline; $T_2 - T_0$, changes at the end of the rehabilitation study endpoint from baseline; $T_6 - T_0$, changes at the end of the follow-up study endpoint from baseline; TCM, traditional Chinese medicine

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