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Effects of home-based telerehabilitation-assisted inspiratory muscle training in patients with idiopathic pulmonary fibrosis: A randomized controlled trial

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Abstract

Background and Objective: There are few studies that have used inspiratory muscle training (IMT) as an intervention for patients with isolated idiopathic pulmonary fibrosis (IPF). This study aimed to investigate and interpret the effects of home-based telerehabilitation-assisted IMT in patients with IPF.

Methods: Twenty-eight participants with IPF took part in the study. Lung function tests, functional exercise capacity by 6-min walk distance (6MWD), dyspnoea perception by modified medical research council dyspnoea scale (mMRC), and inspiratory muscle strength by maximal inspiratory pressure (MIP) were assessed. IMT was performed twice a day, 7 days/week, for 8 weeks. The intervention group ($n = 14$) performed IMT at 50% of their baseline MIP while the control group ($n = 14$) performed IMT without applied resistance. Loading intensity was progressed by keeping the load at 4–6 on a modified Borg scale for the highest tolerable perceived respiratory effort for each patient.

Results: Dyspnoea based on mMRC score ($p < 0.001$, η^2 effect size = 0.48) significantly decreased within the intervention group compared with the control group. There were significant increases in the intervention group compared to the control group based on 6MWD ($p < 0.001$, η^2 effect size = 0.43), MIP ($p = 0.006$, η^2 effect size = 0.25) and MIP % predicted ($p = 0.008$, η^2 effect size = 0.25).

Conclusion: The findings of this study suggest that an 8-week home-based telerehabilitation-assisted IMT intervention produced improvements in inspiratory muscle strength, leading to improvements in functional exercise capacity and dyspnoea.

KEYWORDS
exercise and pulmonary rehabilitation, interstitial lung disease, lung fibrosis, pulmonary fibrosis

INTRODUCTION

Idiopathic pulmonary fibrosis (IPF) is a chronic fibrotic lung disease of unknown cause. The progressive course of the disease leads to early disability and death, with a survival of 2–4 years after diagnosis.[1] While currently available pharmacological treatments can slow disease progression and physical deterioration, they are not able to increase functional capacity.[2] IPF is a chronic progressive interstitial lung disease (ILD) that causes increased symptoms of dyspnoea, dry cough and fatigue, reducing functional capacity and health-related quality of life.[3] Patients with ILD have lower lung compliance, which primarily affects their capacity to respond to an increase in respiratory demand. As a result, the respiratory system is pushed to operate in a less than optimal pressure-volume level, which weakens the inspiratory muscles, leading to increased respiratory muscle effort and dyspnoea.[4]

During exercise, the oxygen demand of the body increases, and therefore, the respiratory system must work harder to supply oxygen to the muscles. The strength of the

inspiratory muscles, particularly the diaphragm, influences their capacity to generate enough force to overcome the respiratory resistance developed during exercise. With an increase in the level of exercise, there is an increased demand by the inspiratory muscles to work harder. Stronger inspiratory muscles handle the workload imposed on them more effectively, which leads to better ventilation of the lungs and delivery of oxygen to the active muscles. Moreover, compared to the healthy participants, patients with chronic lung disease use a larger proportion of the maximal inspiratory pressure (MIP) developed, reflecting the strength of the inspiratory muscles.[5,6] Inspiratory muscle training (IMT) has been shown to be an effective training modality that increases inspiratory muscle strength, reduces dyspnoea and improves functional capacity in patients with chronic obstructive pulmonary disease (COPD).[7] By increasing the strength and endurance of the inspiratory muscles, IMT reduces fatigue of the inspiratory muscles during exercise, thus reducing dyspnoea in COPD patients.[8] A systematic review reported that IMT used as an independent approach, can significantly improve inspiratory muscle function in COPD patients, as well as improve exercise capacity and quality of life and reduce dyspnoea.[8] It has also been demonstrated to increase inspiratory muscle strength and exercise capacity in patients with ILD such as IPF, however, there are few studies that have used IMT as an intervention in patients with isolated IPF.[9–11] To the best of our knowledge, this is the first study to apply home-based telerehabilitation-assisted IMT to patients with IPF. This study aims to investigate and interpret the effects of home-based telerehabilitation-assisted IMT in patients with IPF.

SUMMARY AT A GLANCE

An 8-week home-based telerehabilitation-assisted inspiratory muscle training is an effective intervention that improves respiratory muscle strength and functional exercise capacity and decreases dyspnoea in patients with idiopathic pulmonary fibrosis.

METHODS

Study design and participants

This was a single-centre, randomized controlled trial with concealed allocation, blinded assessors and intention-to-treat analysis. In this study, participants with IPF were included with a 1:1 allocation ratio from May 2022 to August 2022 at the Department of Chest Diseases at Dokuz Eylül University Hospital. Participants were randomly allocated to either an intervention group performing inspiratory muscle training or a control group performing sham inspiratory muscle training for 8 weeks. The assessor and participants were blinded to group allocation for all assessments. Also, an independent and blinded researcher, who had no involvement in subject recruitment, evaluation or training, performed randomization using a sequence generated from the website www.randomizer.org. The inclusion criteria were, having a diagnosis of IPF according to American Thoracic Society/European Respiratory Society (ATS/ERS) guidelines, not having previous or current COVID-19 and having clinically stable condition with the same medication routine and/or no acute exacerbation in the last 4 weeks. Exclusion criteria were, using supplemental oxygen therapy, demonstrating an inability to comprehend or perform the proposed procedures during the evaluations or training program, participating in any pulmonary rehabilitation programs or any exercise training, having undergone a previous pneumonectomy or lobectomy operation, experiencing pneumonia within the last 4 weeks, having a pulmonary infection during the study, or presenting any orthopaedic or neurological conditions that hinder independent walking.

The study was conducted in accordance with the Declaration of Helsinki and its later amendments or comparable ethical standards and approved by the institutional ethical board of Dokuz Eylül University (approval number: 2022/04-03, date: 02.02.2022). All participants gave informed consent before the study.

Assessments

Once the demographic and clinical parameters were recorded, inspiratory muscle strength was assessed as primary outcomes, and lung function, functional exercise capacity and dyspnoea were assessed as secondary outcomes. We followed the CONSORT guidelines for reporting this trial.

Inspiratory muscle strength was evaluated through the utilization of an intraoral pressure measuring device (Sensor Medics Vmax 22 machine, SensorMedics Inc., Anaheim, CA, USA), which captured measurements of maximal inspiratory pressure (MIP) at the mouth, in accordance with the ATS/ERS recommendations.[12] Lung function was measured following a standardized method in accordance with ATS/ERS guidelines using a digital spirometer (Sensor Medics Vmax 22 machine, SensorMedics Inc., Anaheim, CA, USA) by a single experienced respiratory technician, who was not involved in the study. Measures of lung function included forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC) and diffusion capacity for carbon monoxide (DL_{CO}) were assessed and presented as percentages (%) of the predicted values.[13,14] The 6-Min Walk Test (6MWT) was used to evaluate functional exercise capacity. The 6MWT was conducted according to ATS guidelines in a covered, flat, 30-m corridor at the chest diseases department of the hospital.[15] Briefly, all patients were instructed to walk as far as possible in 6 min and the distance covered was recorded. Heart rate and oxygen saturation as measured by pulse oximetry, as well as dyspnoea and fatigue

measured by a modified Borg scale were recorded at baseline and immediately after testing.[16,17] The modified medical research council dyspnoea (mMRC) scale was used to determine dyspnoea in daily living. The mMRC scale consists of five grades (0–4) that evaluate various physiological activities associated with the occurrence of dyspnoea. Upon reviewing the descriptive phrases, the patients proceeded to choose the number that most accurately corresponded to their level of dyspnoea during their daily activities. A high score on the scale indicates a greater degree of dyspnoea.[18,19]

Intervention

Initially, all patients attended a face-to-face practice session to learn diaphragmatic breathing and use the threshold-loaded IMT device (Threshold IMT Philips® Respironics, Inc). Patients allocated to the IMT group trained based on a previously published protocol at a load of 50% of their baseline MIP.[20] Then, loading intensity was progressed by keeping the load at 4–6 on a modified Borg scale for the highest tolerable perceived respiratory effort for each patient.[17,20] However, the control group performed sham training

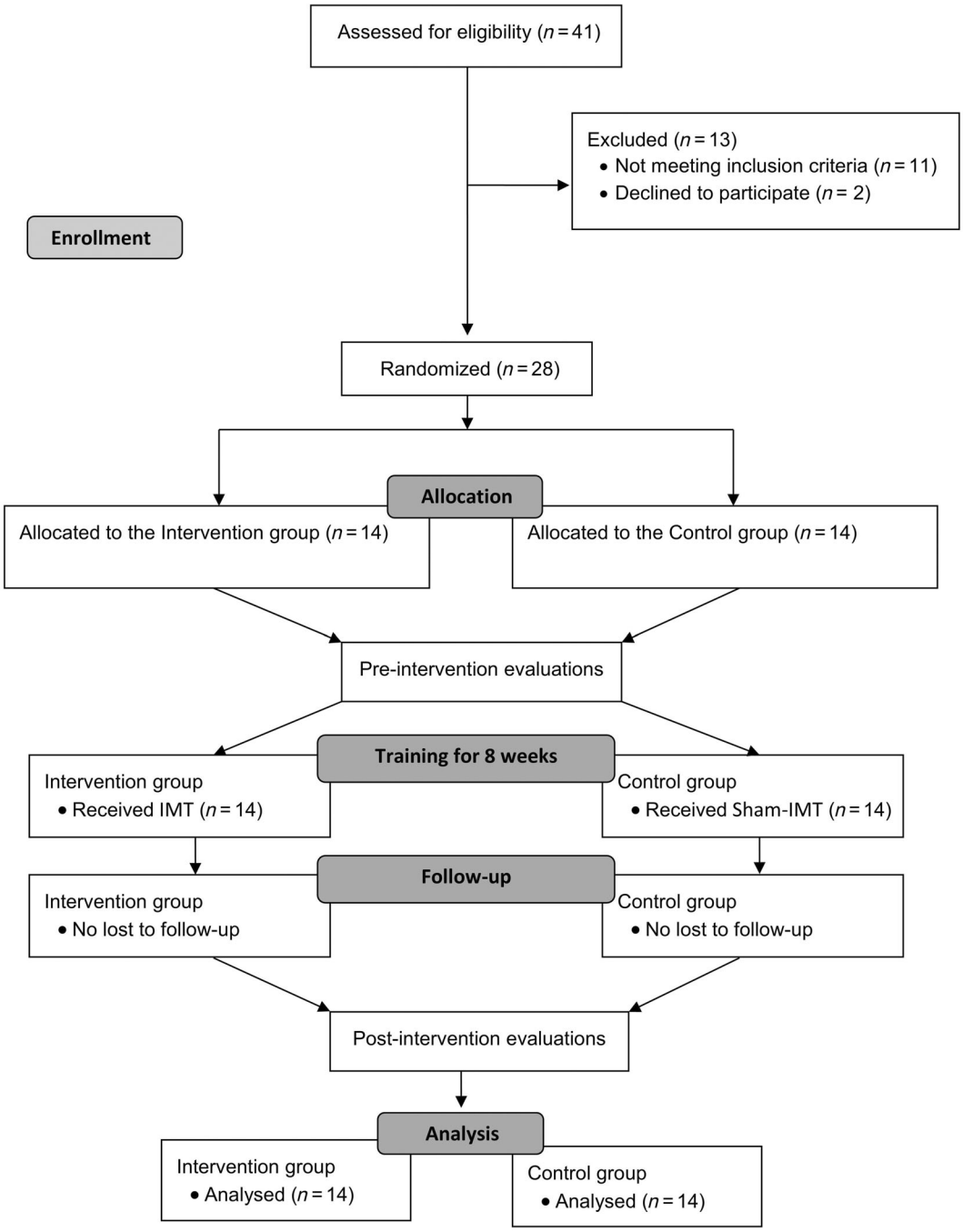

FIGURE 1 Flow chart of the study.

without an inspiratory load (Threshold IMT Philips® Respironics, Inc). Throughout the training sessions, patients were instructed to maintain diaphragmatic breathing. Patients were asked to complete two sets of 30 repetitions, with one-minute rest between each set, twice a day, 7 days/week, for 8 weeks.[20,21] The protocol was performed once a week under the supervision of a physiotherapist as a telerehabilitation session by making video calls at home, and other days at home monitored by a home-based diary. The training load remained the same for 1 week until the following weekly supervised telerehabilitation session. During the weekly supervised telerehabilitation session, the training load was adjusted to the highest tolerable load (i.e., based on a modified Borg score of 4–6) by the same trained physiotherapist. There was no other co-intervention (i.e., whole-body exercise prescription, supplemental oxygen use) in this study.

TABLE 1 Baseline demographic and clinic characteristics of the groups.

	Intervention group ($n = 14$)	Control group ($n = 14$)
Sex, male/female *n* (%)	8/6 (57.1/42.9)	11/3 (78.6/21.4)
Age, years	66.5 ± 5.5	68.9 ± 7.0
Weight, kg	69.9 ± 12.9	72.4 ± 13.6
Height, cm	162.3 ± 8.2	166.2 ± 11.6
BMI, kg/m^2	26.5 ± 5.5	26.1 ± 3.2
Smoking status, *n* (%)		
Current	1 (7.1)	1 (7.1)
Former	8 (57.1)	10 (71.4)
Never	5 (35.7)	3 (21.4)
mMRC score	2.35 ± 0.49	2.14 ± 0.77
6MWD, m	427.9 ± 68.6	412.5 ± 80.5
FEV_1, % predicted	89.8 ± 17.4	84.5 ± 20.1
FVC, % predicted	84.6 ± 16.9	78.6 ± 18.9
DL_{CO}, % predicted	60.2 ± 34.6	52.9 ± 22.1
MIP, cmH_2O	52.8 ± 24.9	53.1 ± 21.7
MIP, % predicted	76.8 ± 36.6	69.5 ± 26.4

Note: Data are expressed as mean ± SD or *n* (%).
Abbreviations: 6MWD, 6-min walk distance; DL_{CO}, diffusing capacity of the lung for carbon monoxide; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; MIP, maximal inspiratory pressure; mMRC, modified medical research council dyspnoea scale.

Statistical analysis

All statistical analyses were performed using SPSS 21.0 (SPSS, Chicago, Illinois). The Shapiro–Wilk test was used to evaluate the normality of the data distribution for each variable, and the natural logarithmic transformation was applied when necessary. The continuous variables are reported as a mean ± SD and 95% CI, and the categorical variables are presented in absolute frequencies and percentages. Nominal data were compared using a chi-square test. The treatment effect was assessed using analysis of covariance (ANCOVA) with baseline values entered as covariates. We reported the estimated marginal means saved from the ANCOVA model and compared the main effects with Bonferroni correction.[22] In addition, the effect sizes were given as eta square (η^2). For eta squared, threshold values are interpreted as small effect (0.01), medium effect (0.06) and large effect (0.14).[23] The significance level was set at 5% for all analyses.

The sample size was calculated based on the MIP improvement of the Kaushal et al.[10] study (mean difference = 17.44 cmH_2O), with an 0.05 α value and 80% power, using the G*Power program.[24] The minimum sample size required to detect a significant difference should be at least a total of 28 patients with 14 per group.

RESULTS

Forty-one patients with IPF were screened to participate in the study. Thirteen of them did not meet the inclusion criteria. Therefore, the study was completed with the final sample of 28 participants, with 14 in each group. There was no loss to follow-up. The study flow is presented in Figure 1.

TABLE 2 Mean difference of values of clinical parameters, by intervention.

	Intervention group ($n = 14$)		Control group ($n = 14$)		Group differences		
Parameters	**Post-intervention**	**95% CI**	**Post-intervention**	**95% CI**	**Mean difference (95% CI)**	**Effect size (η^2)**	***p*-value[a]**
mMRC score	1.13 ± 0.20	0.71–1.54	2.52 ± 0.20	2.10–2.94	−1.39 (−1.99 to −0.80)	*0.48*	<0.001
6MWD, m	460.3 ± 6.0	448.0–472.5	423.7 ± 6.0	411.4–435.9	36.6 (19.2 to 53.9)	*0.43*	<0.001
FEV_1, % predicted	85.5 ± 2.8	82.6–94.2	88.4 ± 2.8	82.6–94.2	−2.9 (−11.1 to 5.4)	*0.02*	0.482
FVC, % predicted	81.9 ± 2.6	76.4–87.3	81.6 ± 2.6	76.1–87.0	0.31 (−7.4 to 8.1)	*0.00*	0.935
DL_{CO}, % predicted	45.3 ± 6.8	31.2–59.4	55.7 ± 6.8	41.6–69.8	−10.4 (−30.4 to 9.6)	*0.04*	0.295
MIP, cmH_2O	72.9 ± 5.9	60.9–84.9	48.1 ± 5.9	36.0–60.1	24.9 (7.9 to 41.9)	*0.27*	0.006
MIP, % predicted	101.7 ± 8.8	83.7–119.8	66.0 ± 8.8	47.9–84.1	35.7 (10.1 to 61.3)	*0.25*	0.008

Note: Data are expressed as Mean ± SE.
Abbreviations: SEM, Standard Error of Mean; η^2, eta square; mMRC, modified medical research council dyspnoea scale; 6MWD, 6-min walk distance; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; DL_{CO}, diffusing capacity of the lung for carbon monoxide; MIP, maximal inspiratory pressure; ANCOVA, Analysis of Covariance.
[a]Differences between groups: ANCOVA, $p < 0.05$ is considered a statistically significant difference in outcome.

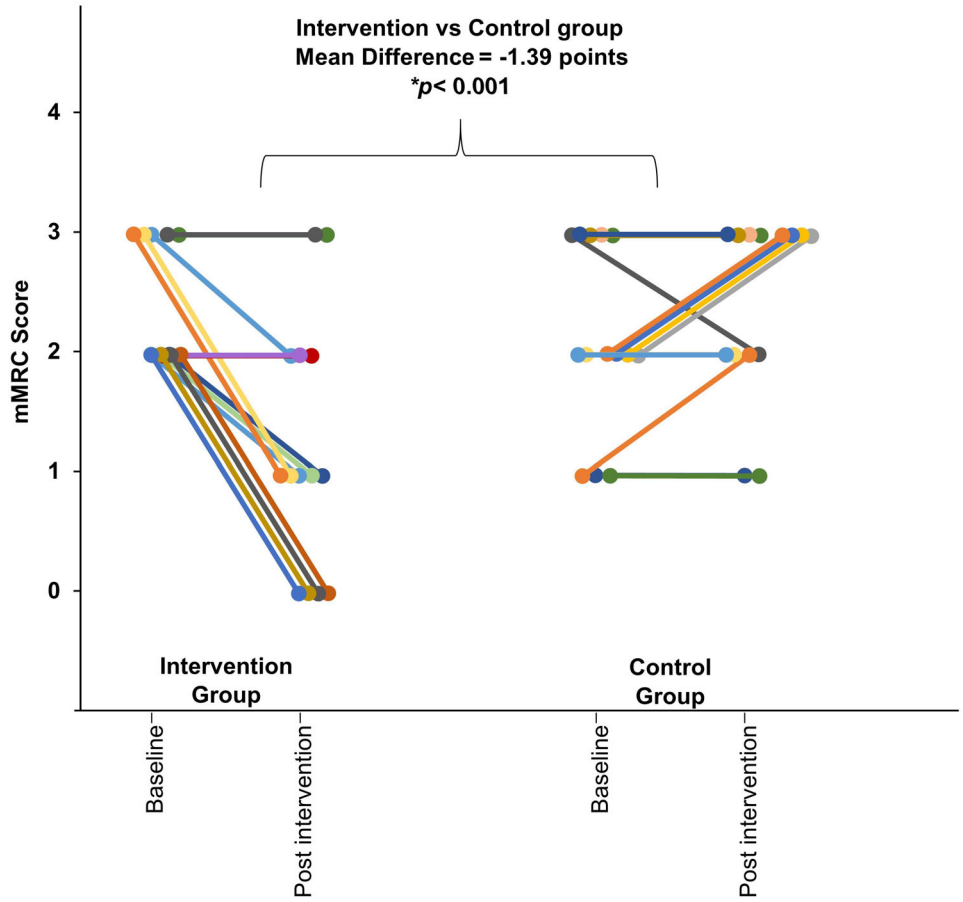

FIGURE 2 Changes in individual mMRC score for each participant with between-group comparison. mMRC, modified medical research council dyspnoea scale. Between groups differences *p*-value was shown based on ANCOVA. $^{*}p < 0.05$.

Demographic and clinical parameters of patients were presented in Table 1. The MIP (Mean Difference = 24.9 cmH_2O, 95% CI = 7.9 to 41.9, η^2 effect size = 0.25) and MIP % predicted (Mean Difference = 35.7, 95% CI = 10.1 to 61.3, η^2 effect size = 0.25) significantly increased within the intervention group compared with the control group (Table 2). However, there were no significant differences between groups in terms of % predicted of FEV_1, FVC and DL_{CO} values after intervention ($p > 0.05$) (Table 2). Dyspnoea based on mMRC score (mean difference = −1.39, 95% CI = −1.99 to −0.80, η^2 effect size = 0.48) significantly decreased within the intervention group compared with the control group (Table 2, Figure 2). Moreover, there was a significant increase in the intervention group compared to the control group based on distance covered during 6MWT (mean difference = 36.6 m, 95% CI = 19.2–53.9, η^2 effect size = 0.43) (Table 2, Figure 3).

DISCUSSION

To the best of our knowledge, this is the first randomized controlled trial that has investigated the effects of home-based telerehabilitation-assisted IMT in patients with IPF. The main findings of this study are that IMT is an effective intervention that improves inspiratory muscle strength and functional exercise capacity, and decreases dyspnoea in patients with IPF.

There are some studies that involve a mixed group of patients with restrictive lung disease or ILD.[11,20,25–29] However, as these studies included a heterogeneous population consisting of restrictive and obstructive lung diseases, their findings could not fully reflect the specific effects of IMT on IPF patients. Kagaya et al.[25] applied a pulmonary rehabilitation program involving inspiratory muscle training as well in patients with restrictive lung disease. They found that pulmonary rehabilitation involving inspiratory muscle training increases inspiratory muscles strength, and quality of life, in addition, reduces both dyspnoea and exercise intolerance. One study investigated a tailored pulmonary rehabilitation program that included IMT in ILD patients and found improvements in exercise capacity and dyspnoea.[26] Kaushal et al.[10] also investigated the effects of a supervised pulmonary rehabilitation program including inspiratory muscle training in patients with ILD. The study program included patient educational sessions, exercise trainings and inspiratory muscle training for 3 days/week for 8 weeks. After 8 weeks of the combined pulmonary rehabilitation program, they found that the patients with ILD had improvements in functional exercise capacity, dyspnoea perception and MIP. A study by Kerti et al.[27] included 71 patients with ILD who performed a complex pulmonary rehabilitation program containing chest wall-

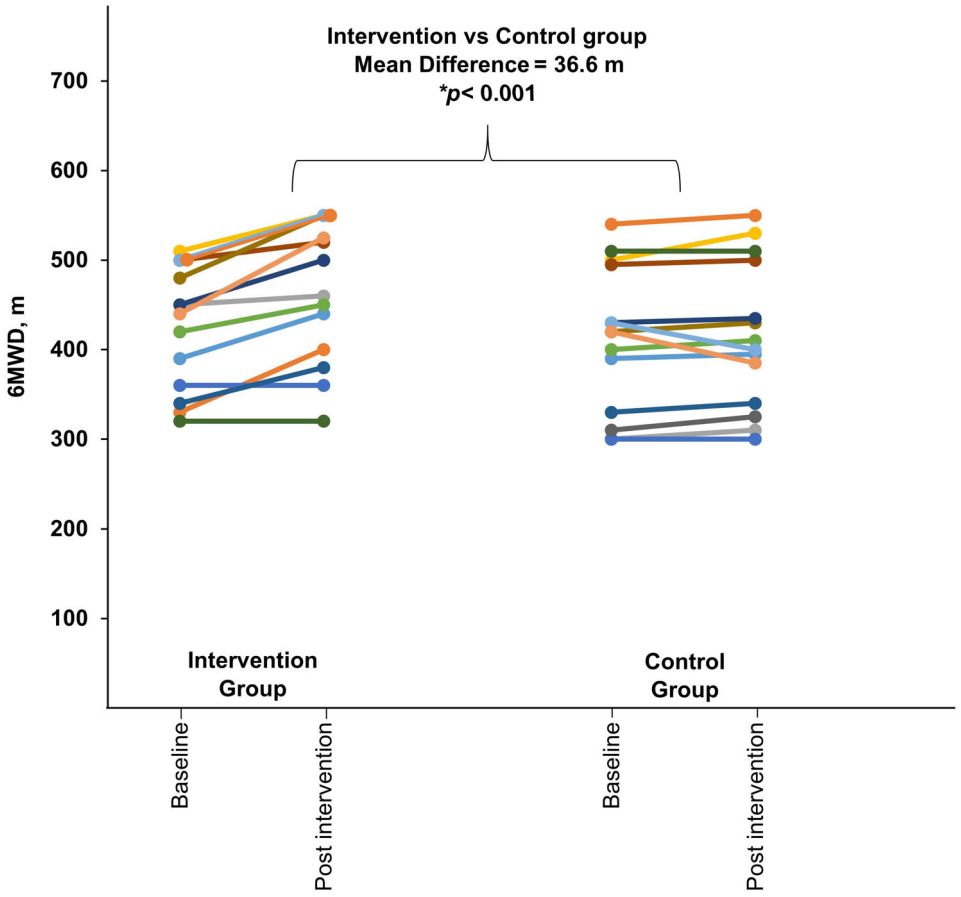

FIGURE 3 Changes in individual 6MWD for each participant with between-group comparison. 6MWD, 6-min walk distance. Between groups differences *p*-value was shown based on ANCOVA. $*p < 0.05$.

stretching, pulmonary exercises and aerobic training 2–3 times/week for 4 weeks with all of them applying the IMT 2 × 10 times per day. They demonstrated that pulmonary rehabilitation with IMT led to increased 6MWD, improved quality of life, enhanced MIP and reduced dyspnoea in ILD patients. However, no significant changes were observed in FVC. A recent interventional study conducted by Hoffman et al.[20] examined the effects of IMT on a mixed lung disease population (COPD, IPF, bronchiectasis, asthma or hypersensitivity pneumonitis). While this study did not include a control group, the findings demonstrated that IMT improved dyspnoea, inspiratory muscle strength and endurance. In their study, participants completed an 8-week home-based high-intensity interval IMT program in sets of 30 breaths, with a 2-min interval between sets. They set the intensity of IMT higher than 50% of MIP and also adjusted the intensity between 4 and 6 using a modified Borg scale. Thus, if the modified Borg score was less than 4 or higher than 6, the training load was adjusted to higher or lower than 50% of the MIP, respectively.[20] The same researchers applied the same program to 10 patients and investigated the effects of IMT in patients with advanced lung disease.[28] They found that there were improvements in dyspnoea, daily activities and mobility. Zaki et al.[11] recently conducted a study to examine the effects of combining IMT with pulmonary rehabilitation in ILD patients. They demonstrate that the group that underwent combined pulmonary rehabilitation with IMT demonstrated greater improvements in functional exercise capacity, quality of life and dyspnoea perception. While there is limited study specifically examining the effects of IMT in patients with ILD particularly in IPF patients, to the best of our knowledge, we have identified only three studies in the literature focusing on the effect of IMT in IPF patients alone.[9,10,30] In an 8-week study by Nykvist et al.,[10] patients with IPF had IMT combined with aerobic exercise. When compared to the control group, they found that both the exercise capacity and dyspnoea perception had significantly improved. Jastrzebski et al.[9] investigated the effects of IMT on dyspnoea, quality of life, functional exercise capacity, MIP and lung function in patients with IPF. They applied IMT combined with general whole body exercises to the study group of 16 IPF patients, while they applied only general whole body exercises to the control group. They found that dyspnoea and MIP improved in the study group. In a case study, a supervised combined training program, which included aerobic training, resistance training and IMT, was applied to a 56-year-old man with IPF. It was shown that supervised combined training including IMT can preserve functionality and quality of life.[31] In our study, we found that an 8-week IMT increases exercise capacity, inspiratory muscle strength and decreases dyspnoea in patients with IPF. However, there were no changes in lung mechanics (FEV_1%, FVC% and DL_{CO}%). Moreover, we found that the study group exceeded the minimally clinically important difference (MCID) of 10.8–58.5 m[32] or 25–45 m[33]

reported for IPF patients with a mean change of 36.6 m in 6DYT compared with the control group. Although the MCID for mMRC was reported as 0.4 points in IPF patients,[34] a change of 1 point in either direction indicates a shift in dyspnoea, meaning worsening (with a higher score) or improvement (with a lower score).[35] Also, a change of at least 18 cmH_2O and 22.1% of that predicted for MIP represented the MCID.[36] In our study, there was a 1.39 point decrease in mMRC, and a 35.7% of that predicted increase in MIP with 24.9 cmH_2O in the intervention group compared to the control group. These findings align with existing literature and, to the best of our knowledge, represent the first randomized controlled study to demonstrate these findings in a population exclusively consisting of IPF patients. Our study found notable enhancements in the 6MWD following IMT alone approach. Comparing our results with previous studies combining IMT and PR, such as Kagaya et al.[25] and Kaushal et al.,[10] which reported significant increases in 6MWD averaging 50 and 38 meters respectively, our study demonstrated a mean difference of 36.6 m with IMT alone. This similarity in improvement suggests that IMT may be the pivotal aspect of rehabilitation programs. This insight is crucial as it highlights the potential for IMT to be prioritized in rehabilitation protocols, possibly leading to more efficient and resource-conserving interventions. Notably, most studies combined IMT + PR in IPF patients used low to moderate IMT loads, remaining below 50%. Only Hoffman et al.[20] using a 50% load similar to ours, yet their study involved a very mixed study population included a group of patients with restrictive and obstructive patterns (more than 50% had obstructive conditions such as COPD and bronchiectasis) classified as advanced lung disease with relatively severe clinical presentations. Therefore, using their results as a basis for IPF patients may be misleading. In our study, the 50% loading threshold was applied only to IPF patients, we think that such a significant improvement in 6MWD in our study is due to above reasons. Our findings suggest that future research should further investigate the relative contributions of IMT and PR to overall functional improvements. Identifying the most effective components of rehabilitation could lead to more efficient and targeted interventions for patients with respiratory conditions.

It's important to note that ILD is a diverse group of disorders, and each type has its unique features and considerations. IPF is a specific type of ILD, and ILD is a broad category that includes various conditions affecting the interstitium, which is the tissue and space around the air sacs in the lungs. There are some key differences between IPF and other interstitial lung diseases. For example, IPF and Sarcoidosis are distinct clinical entities. Fibrotic disease in pulmonary sarcoidosis is typically upper lobe predominant. In IPF, fibrosis is basilar and peripheral predominant (as known the usual interstitial pneumonia pattern). This causes a variety of different symptoms to predominate in each ILD.[31] Thus, the sole inclusion of patients with IPF in the current study provides clinically important findings.

There were indeed limitations to this study worth mentioning. Firstly, the load intensity progression was determined using the modified Borg scale, instead of weekly evaluate the MIP values of the patients. This strategy may restrict the accuracy and precision of load intensity. Secondly, only including clinically stable IPF patients restricts the generalizability of the findings to patients with unstable IPF. Future studies addressing these limitations will help improve the body of literature in this area.

In conclusion, an 8-week home-based telerehabilitation-assisted IMT produced improvements in inspiratory muscle strength, leading to improvements in functional exercise capacity and dyspnoea in patients with IPF. Further studies are needed to determine whether IMT is a supplementary intervention that helps improve the management of IPF.

AUTHOR CONTRIBUTIONS

Rıdvan Aktan: Conceptualization (lead); data curation (lead); formal analysis (lead); investigation (lead); methodology (lead); project administration (equal); resources (supporting); software (lead); writing – original draft (lead); writing – review and editing (equal). **Kemal Can Tertemiz:** Conceptualization (supporting); investigation (supporting); methodology (supporting); project administration (equal); resources (supporting); writing – review and editing (equal). **Salih Yiğit:** Conceptualization (supporting); data curation (supporting); investigation (supporting); methodology (supporting); resources (supporting); writing – review and editing (equal). **Sevgi Özalevli:** Conceptualization (supporting); formal analysis (supporting); investigation (supporting); methodology (supporting); project administration (supporting); writing – review and editing (equal). **Aylin Özgen Alpaydin:** Conceptualization (supporting); methodology (supporting); resources (supporting); supervision (supporting); writing – review and editing (equal). **Eyüp Sabri Uçan:** Conceptualization (supporting); resources (lead); supervision (lead); writing – review and editing (equal).

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CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available due to privacy and ethical restrictions.

HUMAN ETHICS APPROVAL DECLARATION

This study was performed in accordance with the Declaration of Helsinki. This human study was approved by Non-invasive research ethics board of Dokuz Eylul University—approval number: 2022/04-03, date: 02.02.2022. All adult participants provided written informed consent to participate in this study.

Clinical trial registration: NCT05353556 at Clinical Trials.gov.

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REFERENCES

1. Raghu G, Collard HR, Egan JJ, Martinez FJ, Behr J, Brown KK, et al. An official ATS/ERS/JRS/ALAT statement: idiopathic pulmonary fibrosis: evidence-based guidelines for diagnosis and management. Am J Respir Crit Care Med. 2011;183:788–824.
2. Iwanami Y, Ebihara K, Nakao K, Sato N, Miyagi M, Nakamura Y, et al. Benefits of pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis receiving antifibrotic drug treatment. J Clin Med. 2022;11:5336.
3. Selman M, Thannickal VJ, Pardo A, Zisman DA, Martinez FJ, Lynch JP 3rd. Idiopathic pulmonary fibrosis: pathogenesis and therapeutic approaches. Drugs. 2004;64:405–30.
4. Jensen D, Schaeffer MR, Guenette JA. Pathophysiological mechanisms of exertional breathlessness in chronic obstructive pulmonary disease and interstitial lung disease. Curr Opin Support Palliat Care. 2018;12:237–45.
5. Kabitz HJ, Walker D, Schwoerer A, Sonntag F, Walterspacher S, Roecker K, et al. New physiological insights into exercise-induced diaphragmatic fatigue. Respir Physiol Neurobiol. 2007;158:88–96.
6. O'Donnell DE, Bertley JC, Chau L, Webb KA. Qualitative aspects of exertional breathlessness in chronic airflow limitation: pathophysiologic mechanisms. Am J Respir Crit Care Med. 1997;155:109–15.
7. Hill K, Jenkins SC, Hillman DR, Eastwood PR. Dyspnoea in COPD: can inspiratory muscle training help? Aust J Physiother. 2004;50:169–80.
8. Gosselink R, De Vos J, Van Den Heuvel S, Segers J, Decramer M, Kwakkel G. Impact of inspiratory muscle training in patients with COPD: what is the evidence? Eur Respir J. 2011;37:416–25.
9. Jastrzebski D, Kozielski J, Zebrowska A. Pulmonary rehabilitation in patients with idiopathic pulmonary fibrosis with inspiratory muscle training. Pneumonol Alergol Pol. 2008;76:131–41.
10. Kaushal M, Ali MS, Sharma RK, Talwar D. Effect of respiratory muscle training and pulmonary rehabilitation on exercise capacity in patients with interstitial lung disease: a prospective quasi-experimental study. Eurasian J Pulmonol. 2019;21:87–92.
11. Zaki S, Moiz JA, Mujaddadi A, Ali MS, Talwar D. Does inspiratory muscle training provide additional benefits during pulmonary rehabilitation in people with interstitial lung disease? A randomized control trial. Physiother Theory Pract. 2023;39:518–28.
12. American Thoracic Society/European Respiratory Society. ATS/ERS statement on respiratory muscle testing. Am J Respir Crit Care Med. 2002;166:518–624.
13. Macintyre N, Crapo RO, Viegi G, Johnson DC, van der Grinten CP, Brusasco V, et al. Standardisation of the single-breath determination of carbon monoxide uptake in the lung. Eur Respir J. 2005;26:720–35.
14. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. Standardisation of spirometry. Eur Respir J. 2005;26:319–38.
15. ATS Committee on Proficiency Standards for Clinical Pulmonary Function Laboratories. ATS statement: guidelines for the six-minute walk test. Am J Respir Crit Care Med. 2002;166:111–7.
16. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14:377–81.
17. Wilson RC, Jones P. A comparison of the visual analogue scale and modified Borg scale for the measurement of dyspnoea during exercise. Clin Sci. 1989;76:277–82.
18. Mahler DA, Wells CK. Evaluation of clinical methods for rating dyspnea. Chest. 1988;93:580–6.
19. Nishiyama O, Taniguchi H, Kondoh Y, Kimura T, Kato K, Kataoka K, et al. A simple assessment of dyspnoea as a prognostic indicator in idiopathic pulmonary fibrosis. Eur Respir J. 2010;36:1067–72.
20. Hoffman M, Augusto VM, Eduardo DS, Silveira BMF, Lemos MD, Parreira VF. Inspiratory muscle training reduces dyspnea during activities of daily living and improves inspiratory muscle function and quality of life in patients with advanced lung disease. Physiother Theory Pract. 2021;37:895–905.
21. McConnell A. Chapter 6—Implementing respiratory muscle training. In: McConnell A, editor. Respiratory muscle training: theory and practice. Oxford: UK, Churchill Livingstone; 2013. p. 149–73.
22. Van Breukelen GJ. ANCOVA versus change from baseline: more power in randomized studies, more bias in nonrandomized studies [corrected]. J Clin Epidemiol. 2006;59:920–5.
23. Adams MA, Conway TL. Eta squared. In: Michalos AC, editor. Encyclopedia of quality of life and well-being research. Netherlands, Dordrecht: Springer; 2014. p. 1965–6.
24. Erdfelder E, Faul F, Buchner A. GPOWER: a general power analysis program. Behav Res Methods Instrum Comput. 1996;28:1–11.
25. Kagaya H, Takahashi H, Sugawara K, Kasai C, Kiyokawa N, Shioya T. Effective home-based pulmonary rehabilitation in patients with restrictive lung diseases. Tohoku J Exp Med. 2009;218:215–9.
26. AlQuaimi M, McNeillie L, Donaldson C, Harper J, Hartley J, Cassidy S, et al. P159 preliminary experience of a tailored ild pulmonary rehabilitation program and inspiratory muscle training delivered in a hospice and home setting. Thorax. 2017;72:A170-A.
27. Kerti M, Bayer B, Tóth B, Varga JT. The effect of inspiratory muscle training in interstitial lung diseases. Eur Respir J. 2020;56:99.
28. Hoffman M, Assis MG, Augusto VM, Silveira BMF, Parreira VF. The effects of inspiratory muscle training based on the perceptions of patients with advanced lung disease: a qualitative study. Braz J Phys Ther. 2018;22:215–21.
29. Hoffman M. Inspiratory muscle training in interstitial lung disease: a systematic scoping review. J Bras Pneumol. 2021;47:e20210089. https://doi.org/10.36416/1806-3756/e20210089
30. Naranjo-Orellana J, Santalla A. Long-term combined training in idiopathic pulmonary fibrosis: a case study. Int J Environ Res Public Health. 2020;17:17.
31. Collins BF, McClelland RL, Ho LA, Mikacenic CR, Hayes J, Spada C, et al. Sarcoidosis and IPF in the same patient—a coincidence, an association or a phenotype? Respir Med. 2018;144s:S20–7.
32. Swigris JJ, Wamboldt FS, Behr J, Du Bois RM, King TE, Raghu G, et al. The 6 minute walk in idiopathic pulmonary fibrosis: longitudinal changes and minimum important difference. Thorax. 2010;65:173–7.
33. du Bois RM, Weycker D, Albera C, Bradford WZ, Costabel U, Kartashov A, et al. Six-minute-walk test in idiopathic pulmonary fibrosis: test validation and minimal clinically important difference. Am J Respir Crit Care Med. 2011;183:1231–7.
34. Kim JW, Clark A, Birring SS, Atkins C, Whyte M, Wilson AM. Psychometric properties of patient reported outcome measures in idiopathic pulmonary fibrosis. Chron Respir Dis. 2021;18:14799731211033925. https://doi.org/10.1177/14799731211033925
35. Duke JD, Roy M, Daley S, Hoult J, Benzo R, Moua T. Association of patient-reported outcome measures with lung function and mortality in fibrotic interstitial lung disease: a prospective cohort study. ERJ Open Res. 2024;10:00591-2023.
36. Del Corral T, Fabero-Garrido R, Plaza-Manzano G, Fernández-de-Las-Peñas C, Navarro-Santana MJ, López-de-Uralde-Villanueva I. Minimal clinically important differences in inspiratory muscle function variables after a respiratory muscle training programme in individuals with long-term post-covid-19 symptoms. J Clin Med. 2023;12:2720.

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