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LETTER TO THE EDITOR

# Benefits of inspiratory muscle training in patients with pulmonary hypertension: A pilot study☆

**KEYWORDS**
inspiratory muscle training;
dyspnea;
quality of life;
pulmonary hypertension;
heart failure

Pulmonary hypertension (PH) is characterized by high blood pressure of the pulmonary vasculature and deterioration of right ventricular function.[1] Although not historically prescribed, recent evidence suggests that exercise training may partially reverse symptoms of muscle fatigue and dyspnea, improving exercise tolerance and daily life activities.[2, 3] Furthermore, a decrease in inspiratory muscle function has been reported when assessed with both volitional and non-volitional tests, which correlated with a decrease in exercise capacity evaluated by the 6-min walking test (6MWT).[4] However, evidence of the potential benefits of inspiratory muscle training (IMT) in PH is limited.[5] We hypothesized that IMT could improve inspiratory muscle function, dyspnea, exercise capacity and health-related QoL (HRQoL) in a group of patients with PH.

Patients were included in the study if they were medically stable and had a confirmed diagnosis of PH based on elevated pulmonary artery pressure measured by right heart catheterisation at rest and echocardiography performed by cardiologists who were blind to the study. Patients (n = 10) were randomized to an IMT group (IMTG, n = 5) or a control group (CG, n = 5). The IMTG underwent supervised high-intensity IMT, while patients in the CG did not undergo training. Pre- and post-training all patients were evaluated for inspiratory muscle function, lung volume, exercise capacity, dyspnea and HRQoL. At baseline patients' inspiratory muscle function was compared with that of 10 normal subjects (NS) randomly assigned from the hospital staff.

All experimental procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000. The protocol was approved by the Hospital Ethics Committee, and written informed consent was obtained from all subjects prior to study entry.

Measurements of maximal inspiratory pressure ($PI_{max}$) and inspiratory work capacity (sustained maximal inspiratory pressure, $SPI_{max}$) were made using an electronic pressure manometer and computer software (Trainair®, Project Electronics Ltd., London, U.K).[6] Dynamic lung volumes were measured in the sitting position using a Jaeger system (Masterlab, Jaeger, Wuerzberg, Germany). Exercise capacity was assessed with the 6MWT and dyspnea with the Borg scale (0-10) at the end of the 6MWT. HRQoL was assessed by the Short Form Health Survey (SF36v2®) questionnaire, which consists of 36 items representing 8 subscales that cover the domains of physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), mental health (MH) and reported health transition (HT).[7] IMT was performed with an inspiratory-incremental resistive loading device as previously described (Trainair®, Project Electronics Ltd, U.K). [6, 8] Patients in the IMTG were exercised at 60% of individual $SPI_{max}$ for 30 min, 3 times a week for 10 weeks in the hospital.

All continuous variables are expressed as the mean ± standard deviation of the mean (m ± SD). Baseline comparisons between groups were performed using Student's t-test and the chi-square test. The paired t-test was used to assess training-induced changes (pre vs. post) within a particular group and the repeated measures analysis of variance (RMANOVA) for between groups. Statistical analyses were performed using SPSS software (version 18, SPSS Inc., Chicago, Illinois, USA).

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Our results show that at baseline, patients in the two groups did not differ significantly in their demographic and clinical characteristics (Table 1). Patients and NS were also matched for gender (PH, males/females, 4/6 vs. NS, males/females 5/5, p = ns), age (PH, 54.6 ± 13.4 vs. NS, 53.8 ± 8.4 yrs, p = ns) and body mass index (PH, 26.4 ± 4.7 vs. NS, 28.1 ± 3.3, kg/m$^2$, p = ns). Both $PI_{max}$ and $SPI_{max}$ were significantly reduced in patients with PH compared with NS (PH, 68.5 ± 14.4 vs. NS, 101.3 ± 7.6, $cmH_2O$, $p < 0.001$), (PH, 282 ± 60 vs. NS, 596 ± 28, $cmH_2O/s/10^3$, $p < 0.001$), respectively. The IMTG increased significantly $PI_{max}$ (94.4 ± 16.8 vs. 63.8 ± 16.9 $cmH_2O$, p = 0.004) and $SPI_{max}$ (412.8 ± 38 vs. 261.6 ± 63 $cmH_2O/s/10^3$, p = 0.009), while in the CG no significant changes were detected in $PI_{max}$ (71.4 ± 11.3 vs. 73.2 ± 11 $cmH_2O$, p = ns), or $SPI_{max}$, (302 ± 61 vs. 300 ± 56 $cmH_2O/s/10^3$ p = ns). No significant changes were shown in dynamic lung volume evaluated by spirometry for any of the groups. Patients in the IMTG increased their 6MWT distance (436 ± 95 vs. 391 ± 94 m, p = 0.008) with less dyspnea (Borg scale, 2 ± 1 vs. 4.2 ± 1.9, p = 0.03). No significant changes were noted in the CG ([6MWT, 376 ± 109 vs. 384 ± 117 m, p = ns]; [Borg scale, 3.6 ± 1.3 vs. 3.8 ± 1.3, p = ns]). IMTG significantly improved the SF36v2® questionnaire (p = 0.004) as well as the subscales of the physical component PF (p = 0.001), RP (p = 0.002), the subscale of the mental component SF (p = 0.03) and the HT (p = 0.01). No significant changes were found in the CG (Figure 1). A between-groups analysis did not reveal significant differences for any of the parameters tested.

Thus, IMT resulted in an improvement in inspiratory muscle indices associated with benefits in walking distance, dyspnea and HRQoL in PH patients, confirming our hypothesis. Our findings are very encouraging, since previous

**Table 1** Demographic and clinical characteristics of patients at baseline.

| | IMTG (n = 5) | CG (n = 5) | p |
|---|---|---|---|
| Age (yrs) | 48.6 ± 12.7 | 60.6 ± 12.4 | ns |
| Gender | Males (1)/Females (4) | Males (3)/Females (2) | ns |
| BMI (kg/m$^2$) | 28.3 ± 4.2 | 24.5 ± 4.9 | ns |
| WHO (I-IV) functional class | 2.6 ± 0.5 | 2.4 ± 1.1 | ns |
| SPAP (mmHg) *(invasive)* | 76.6 ± 30.8 | 90 ± 28 | ns |
| RVSP (mmHg) *(echo)* | 81.4 ± 22 | 93.2 ± 27 | ns |
| Aetiology | Group I (n = 5) | Group IV (n = 3), Group I (n = 2) | ns |
| Medication | | | ns |
| ERA | 2 | 3 | |
| PDE-5I | 1 | 2 | |
| Prostanoids | 1 | 0 | |
| Anticoagulants | 3 | 3 | |
| Diuretics | 2 | 1 | |
| Antidepressants | 1 | 1 | |
| CCB | 2 | 0 | |

IMTG, inspiratory muscle training group; CG, control group; BMI, body mass index; SPAP, systolic pulmonary artery pressure; RVSP, right ventricular systolic pressure; Group I (idiopathic n = 2, associated with scleroderma n = 2, pulmonary venous obstruction disease n = 1, ventricular septum defect n = 1, portal hypertension n = 1) and Group IV (chronic thromboembolic n = 3); ERA, endothelium receptor antagonist; PDE-5I, phosphodiesterase-5Inhibitors; CCB, calcium channel blockers

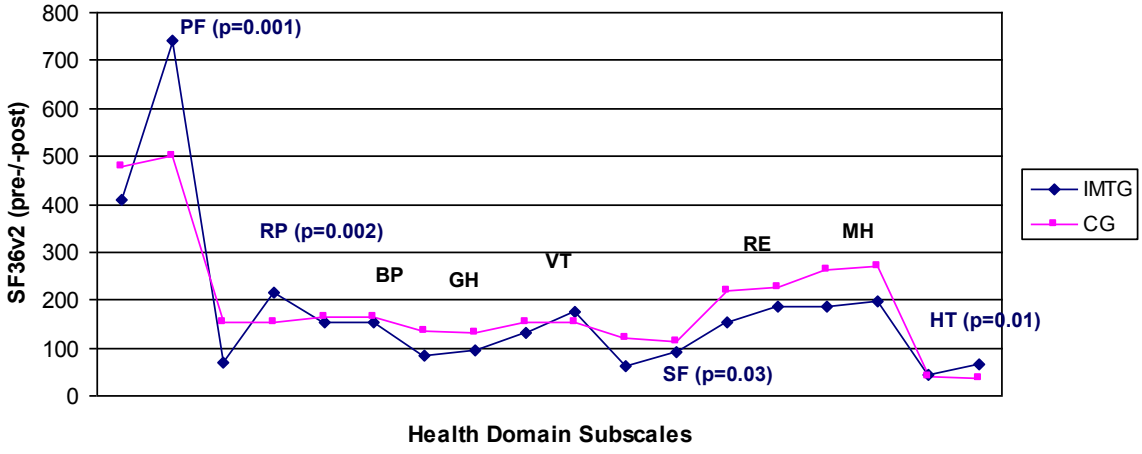


**Figure 1** Quality of life questionnaire recordings pre-and post- for the inspiratory muscle training group (IMTG) and the control group (CG). PF, Physical Functioning; RP, Role-Physical; BP, Bodily Pain; GH, General Health; VT, Vitality; SF, Social Functioning; RE, Role Emotional; MH, mental health; HT, Reported Health Transition.

studies also report benefits of exercise training in patients with PH [2, 3] and are in agreement with recent findings of an IMT-induced improvement in the functional capacity of this population [5]. Inspiratory muscle function was also found to be reduced in patients with PH compared with normal subjects. The reasoning behind this decrease has not been investigated thoroughly until now. Potential reasons include, similarly to left heart failure, peripheral muscle myopathy and/or decreased perfusion of the respiratory muscles resulting in muscle fiber transformation and atrophy. Furthermore, muscle weakness together with a correlation between limb and inspiratory muscle strength have been reported in patients with PH, suggesting generalized myopathy.[9]

Respiratory muscle weakness could contribute to impairment in ventilatory capacity and dyspnea [10] and thus to a decrease in exercise capacity. Improvement in inspiratory muscle function was associated with an improvement in exercise capacity in our patients and most importantly in their QoL. Factors that may lead to impaired QoL in patients with PH include dyspnea, functional limitations, adverse effects of therapy, social isolation, and emotional issues such as anxiety and depression. [11] In this study, we have shown that supervised IMT in PH patients provides beneficial psychological and physical effects. We have previously shown that IMT improved inspiratory muscle indices and functional status of left heart failure petients.[6] It is clear that this is a pilot study limited by the small patient number. However, our findings may stimulate initiation of further studies in a larger cohort of patients.

Patients with PH appear to have weaker inspiratory muscles compared with healthy subjects. IMT shows promise as a safe and potential adjunct therapy in these patients, improving dyspnea, exercise capacity and life quality.

## Conflicts of Interest

None

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