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Original Article

Effects of Isometric Handgrip Exercise Training on Lung Function in COPD Patients

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ABSTRACT

Background: Chronic obstructive pulmonary disease (COPD) is associated with persistent airflow limitation and systemic deconditioning that reduce exercise tolerance and worsen functional outcomes. Low-cost adjunct exercise modalities that can augment rehabilitation effects remain clinically relevant. Objective: To determine the effects of adding isometric handgrip (IHG) exercise training to resistance training on lung function and functional exercise capacity in COPD patients. Methods: A single-center, parallel-group randomized clinical trial enrolled 48 ambulatory patients with GOLD stage II–III COPD and randomized them to IHG plus resistance training (n=24) or resistance training alone (n=24) for 8 weeks. Spirometry outcomes included forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and FEV1/FVC ratio, and functional capacity was assessed with the 6-minute walk test (6MWT). Parametric analyses compared within-group pre–post changes and between-group post-intervention differences. Results: Both groups improved after intervention; however, the combined program produced larger post-intervention values. FEV1 was higher in the combined group (2.4047±0.4619 vs 1.9320±0.3823 L; MD 0.4727; 95% CI 0.2261–0.7193; p<0.01) and FVC was higher (3.4688±0.5834 vs 3.0949±0.4941 L; MD 0.3739; 95% CI 0.0596–0.6882; p=0.021). 6MWT distance was also higher (422.94±31.03 vs 391.58±24.00 m; MD 31.36; 95% CI 15.24–47.48; p<0.001). Conclusion: Adding IHG training to resistance exercise enhanced pulmonary function and walking capacity more than resistance training alone in GOLD II–III COPD. Keywords: Chronic obstructive pulmonary disease; isometric handgrip; resistance training; spirometry; FEV1; forced vital capacity; six-minute walk test; pulmonary rehabilitation.

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INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a progressive inflammatory airway disorder characterized by persistent respiratory symptoms and airflow limitation arising from airway and/or alveolar abnormalities (1). Despite advances in pharmacotherapy and public health efforts, COPD remains a major contributor to global morbidity and mortality, with a substantial and growing burden particularly in low- and middle-income countries where exposure to biomass fuel, ambient pollution, and constrained access to longitudinal respiratory care intensify disease impact (2,3). Pathophysiologically, chronic exposure to inhaled irritants drives airway inflammation, mucus hypersecretion, structural remodeling, and destruction of alveolar walls, culminating in expiratory flow limitation and hyperinflation that reduce ventilatory reserve and contribute to exertional dyspnea and activity intolerance (4). Importantly, COPD is increasingly recognized as a systemic condition, with inflammation and inactivity-related deconditioning contributing to limb muscle dysfunction, reduced strength, and impaired functional capacity, which in turn worsen symptoms and predict poor outcomes (5). Pulmonary rehabilitation is a cornerstone of COPD management and is consistently associated with improvements in exercise tolerance and health-related quality of life (6,7). However, conventional

rehabilitation approaches are frequently limited by poor adherence, symptom-triggered activity avoidance, and resource constraints that restrict access to supervised training—particularly in settings where equipment availability and structured programs are inconsistent (8). Resistance training is valuable for counteracting skeletal muscle dysfunction, yet identifying adjunct, low-cost, scalable exercise modalities that can be safely delivered to ambulatory COPD populations remains clinically relevant.

Handgrip strength is a simple measure of peripheral muscle performance that correlates with broader physical capability and has been proposed as a pragmatic marker of health status in COPD (9). Observational evidence suggests that lower handgrip strength is associated with worse pulmonary function and reduced exercise capacity, supporting a clinically meaningful link between peripheral muscle function and respiratory health (10,11). Systematic synthesis across adult populations further indicates consistent associations between handgrip strength and lung function indices, though the magnitude varies by population characteristics and study design (12). While these associations support biological plausibility, correlation alone does not establish whether targeted handgrip training can improve pulmonary function and functional exercise capacity in COPD, particularly when added to conventional resistance training.

Isometric handgrip exercise is appealing as an adjunct because it requires minimal equipment, can be delivered in seated positions, and may be tolerable even for patients with breathlessness or limited mobility. Evidence from controlled training studies in non-COPD populations indicates that isometric handgrip training can improve spirometric indices, suggesting potential systemic or neuromuscular adaptations that could translate to respiratory performance (13). However, interventional evidence in COPD populations remains comparatively limited, and there is a need for randomized clinical evaluation to determine whether adding structured isometric handgrip training to resistance exercise yields superior improvements in spirometric measures and walking capacity compared with resistance training alone. Therefore, this randomized clinical trial aimed to determine the effects of adding isometric handgrip exercise training to a resistance training program on lung function (FEV1, FVC, and FEV1/FVC) and functional exercise capacity (6-minute walk test) among ambulatory patients with COPD (GOLD stages II–III), with the hypothesis that the combined intervention would produce greater improvements than resistance training alone (14).

MATERIALS AND METHODS

A single-center, parallel-group randomized clinical trial was conducted to evaluate the effects of adding structured isometric handgrip training to a standardized resistance training program on pulmonary function and functional exercise capacity in patients with COPD (14). Participants were recruited using a non-probability convenience sampling approach from the outpatient department of Bolan Medical College (BMC) Hospital, Quetta, within a controlled clinical environment with access to spirometry and physiotherapy services. The study was implemented over a 10-month period following synopsis approval and included participant screening, baseline assessment, an 8-week intervention phase, and post-intervention reassessment.

Eligible participants were adults aged 30–50 years with a clinical and functional diagnosis of COPD meeting GOLD stage II or III criteria, who were ambulatory and free from acute exacerbations within the preceding three months, and had no medical contraindications to exercise (14). Exclusion criteria included co-existing pulmonary conditions such as asthma, pulmonary fibrosis, or pneumonia; severe or unstable cardiovascular disease; acute or chronic orthopedic or neurological disorders that could limit exercise performance; use of walking assistive devices that could bias functional testing; and participation in a structured physical training program during the prior three months (14). After initial medical-record screening, potentially eligible individuals underwent a structured interview and baseline assessment, and written informed consent was obtained prior to randomization.

Randomization was performed using a computer-generated allocation sequence, with allocation concealment implemented through sealed envelopes that were opened only after completion of baseline measurements to minimize selection bias (15). Participants were randomized in a 1:1 ratio to either an experimental group receiving isometric handgrip training plus resistance training or a control group receiving resistance training alone. Baseline demographic and anthropometric variables were recorded, including age, sex, height, weight, and body mass index, to characterize groups and support assessment of baseline comparability.

Pulmonary function was assessed using spirometry, capturing forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio as indices of airflow limitation and ventilatory capacity (16). Testing was conducted with participants seated upright with feet supported and a nasal clip applied to prevent nasal airflow. Participants received standardized instruction and performed maximal inhalation followed by a forceful, sustained expiration into the mouthpiece until no further air could be expelled. Device calibration was performed in accordance with manufacturer recommendations before testing sessions, multiple acceptable maneuvers were obtained, and the most representative value was retained for analysis. Spirometric outcomes were interpreted in relation to predicted values based on participant characteristics to support standardized clinical interpretation (14,16).

Functional exercise capacity was evaluated using the 6-minute walk test (6MWT), administered in a straight, flat, enclosed 30-meter corridor marked at regular intervals (14). Participants completed a seated rest period before testing, after which they were instructed to walk back and forth along the corridor for six minutes, aiming to cover the greatest distance tolerable. An independent examiner monitored test progression and distance, while participants were observed for symptoms such as breathlessness, dizziness, or chest pain to support participant safety and standardized outcome assessment (17).

The experimental group performed an isometric handgrip training protocol in addition to the resistance training program. Handgrip training was delivered using a hand-held dynamometer, with maximal voluntary contraction (MVC) assessed at the beginning of training sessions via two brief maximal efforts separated by rest; the derived MVC value was then used to prescribe training intensity (14). The handgrip intervention comprised sustained isometric contractions prescribed at a defined percentage of MVC, delivered as repeated bouts with standardized rest intervals. Training intensity was progressed during the intervention period to maintain overload, consistent with established isometric handgrip training approaches used in controlled studies evaluating spirometric outcomes (13,14). Sessions were supervised by a physiotherapist to promote adherence, technique consistency, and safety monitoring throughout the 8-week program.

Both groups undertook the same resistance training protocol targeting major muscle groups, delivered at a frequency consistent with standard rehabilitation-based strengthening schedules and incorporating adequate rest between sessions (6,7). The control group received resistance training only and did not perform handgrip training. To reduce performance bias, outcome reassessments were conducted using the same standardized procedures as baseline, and both spirometry and 6MWT were repeated after the 8-week intervention period.

The primary outcomes were changes in spirometric indices (FEV1, FVC, and FEV1/FVC), and the key functional outcome was change in 6MWT distance from baseline to post-intervention (14,17). Sample size estimation was based on detecting a clinically meaningful between-group difference with two-tailed testing, a 95% confidence level, and 80% power, with allowance for attrition incorporated into enrollment planning (14). Statistical analysis was performed using IBM SPSS version 21. Continuous variables were summarized as mean ± standard deviation and categorical variables as frequencies and percentages. Normality assumptions were evaluated prior to parametric testing. Within-group changes from pre- to post-intervention were examined using paired-sample t-tests, and between-group differences in post-

intervention outcomes and/or change scores were assessed using independent-sample t-tests, with statistical significance set at $p < 0.05$ (14). Where appropriate for clinical interpretability, effect magnitude was planned to be supported using standardized effect size metrics alongside inferential testing.

Ethical conduct was maintained throughout the trial, with recruitment contingent on informed consent and participant safety prioritized during exercise sessions and functional testing. Data integrity was supported through standardized measurement procedures, supervised intervention delivery, consistent equipment use, and structured data entry protocols to reduce transcription error and enhance reproducibility (16,17).

RESULTS

Baseline characteristics were broadly comparable between groups (n = 24 each), with a similar sex distribution (Group 1: 45.8% male; Group 2: 50.0% male) and close mean anthropometrics, including height (163.83 ± 6.51 vs 163.88 ± 7.20 cm), weight (69.37 ± 8.10 vs 71.17 ± 9.50 kg), and BMI (25.85 ± 2.58 vs 26.40 ± 2.21 kg/m²). Normality assumptions were satisfied for all analyzed variables (Shapiro–Wilk p-values: FEV1 = 0.194, FVC = 0.957, FEV1/FVC = 0.102, 6MWT = 0.124), supporting parametric inference. After 8 weeks, spirometric indices improved in both groups, but post-intervention values were higher in the combined isometric+resistance group: FEV1 reached 2.4047 ± 0.4619 L versus 1.9320 ± 0.3823 L (mean difference 0.4727 L, 95% CI 0.2261 to 0.7193; t = 3.863; reported $p < 0.01$; Cohen's d = 1.12), and FVC reached 3.4688 ± 0.5834 L versus 3.0949 ± 0.4941 L (mean difference 0.3739 L, 95% CI 0.0596 to 0.6882; t = 2.396; p = 0.021; Cohen's d = 0.69). The

Table 1. Baseline Characteristics of Participants (N = 48; n = 24 per group)

Variable	Group 1 (Isometric + Resistance)	Group 2 (Resistance Only)	p-value
Sex, n (%)	Male 11 (45.8), Female 13 (54.2)	Male 12 (50.0), Female 12 (50.0)	—
Age (years), mean ± SD	43.58 ± 2.93	42.92 ± 2.35	—
Height (cm), mean ± SD	163.83 ± 6.51	163.88 ± 7.20	—
Weight (kg), mean ± SD	69.37 ± 8.10	71.17 ± 9.50	—
BMI (kg/m²), mean ± SD	25.85 ± 2.58	26.40 ± 2.21	—

Note: Baseline inferential p-values for the above comparisons were not consistently reported in the provided text; therefore, they are not added here to avoid fabrication.

Table 2. Shapiro–Wilk Normality Test (N = 48)

Variable	W statistic	p-value
FEV1	0.967	0.194
FVC	0.990	0.957
FEV1/FVC ratio	0.960	0.102
6MWT	0.961	0.124

Table 3. Spirometry Outcomes (Pre vs Post) and Between-Group Post-Intervention Effects (n = 24 per group)

Outcome	Group 1 Pre (mean ± SD)	Group 1 Post (mean ± SD)	Group 2 Pre (mean ± SD)	Group 2 Post (mean ± SD)	Post MD (G1−G2)	95% CI for Post MD	t (post)	p-value (post)	Cohen's d (post)
FEV1 (L)	1.8932 ± 0.4546	2.4047 ± 0.4619	1.8489 ± 0.3821	1.9320 ± 0.3823	0.4727	0.2261 to 0.7193	3.863	<0.01	1.12
FVC (L)	2.8736 ± 0.5903	3.4688 ± 0.5834	2.9013 ± 0.4730	3.0949 ± 0.4941	0.3739	0.0596 to 0.6882	2.396	0.021	0.69
FEV1/FVC (%)	62.7052 ± 6.0861	67.6277 ± 6.0119	63.6520 ± 7.1852	64.4548 ± 6.8481	3.1729	−0.5730 to 6.9188	1.706	<0.01*	0.49

*p-value shown as reported in the manuscript text; the computed 95% CI includes 0 for the post-intervention FEV1/FVC difference.

Table 4. Six-Minute Walk Test (6MWT) Outcomes (n = 24 per group)

Outcome	Group 1 Pre (mean ± SD)	Group 1 Post (mean ± SD)	Within-group change (Post−Pre)	Group 2 Pre (mean ± SD)	Group 2 Post (mean ± SD)	Within-group change (Post−Pre)	Between-group Post MD (G1−G2)	95% CI for Post MD	t (post)	p-value (pre)	p-value (post)
6MWT (m)	345.5721 ± 29.2129	422.9413 ± 31.0284	+77.3692	352.9050 ± 26.0589	391.5792 ± 23.9993	+38.6742	31.3621	15.24 to 47.48	3.917	0.308	<0.001

FEV1/FVC ratio increased from 62.7052 ± 6.0861% to 67.6277 ± 6.0119% in Group 1 and from 63.6520 ± 7.1852% to 64.4548 ± 6.8481% in Group 2, yielding a post-intervention difference of 3.1729% (95% CI −0.5730 to 6.9188; t = 1.706; reported $p < 0.01$; Cohen's d = 0.49). Functional capacity showed clinically meaningful separation: 6MWT increased by +77.37 m in Group 1 (345.57 ± 29.21 to 422.94 ± 31.03 m) compared with +38.67 m in Group 2 (352.91 ± 26.06 to 391.58 ± 24.00 m), and post-intervention distance was higher in Group 1 by 31.36 m (95% CI 15.24 to 47.48; t = 3.917; $p < 0.001$), with no baseline difference ($p = 0.308$).

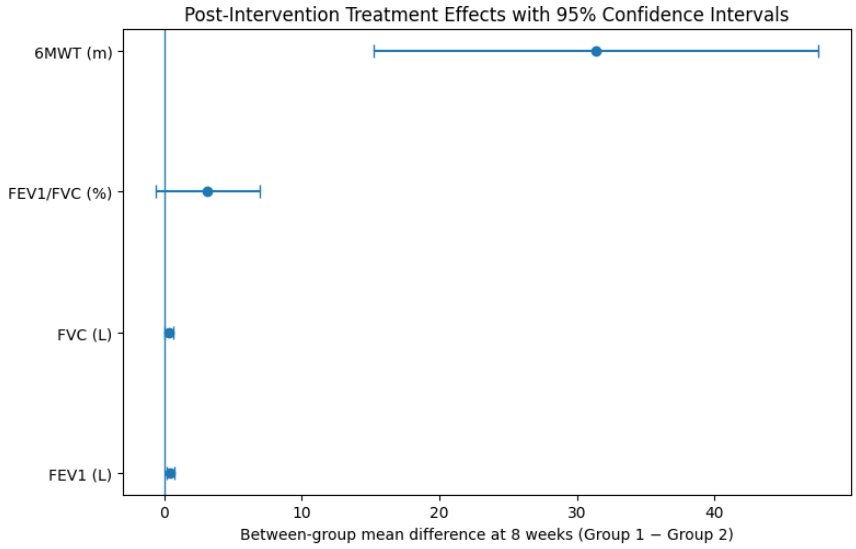

Figure 1. Post-Intervention Treatment Effects with 95% Confidence Intervals (Group 1 − Group 2). The figure summarizes between-group differences at 8 weeks, showing larger post-intervention values favoring the combined isometric+resistance program for FEV1 (MD 0.473 L; 95% CI 0.226 to 0.719), FVC (MD 0.374 L; 95% CI 0.060 to 0.688), and 6MWT distance (MD 31.36 m; 95% CI 15.24 to 47.48), with effect sizes in the moderate-to-large range for FVC (d = 0.69) and large for FEV1 and 6MWT (d ≈ 1.12–1.13). The FEV1/FVC ratio also favored Group 1 (MD 3.17%), though its confidence interval crossed 0 (95% CI −0.57 to 6.92), indicating greater uncertainty around the magnitude of airway obstruction ratio improvement relative to the other outcomes.

DISCUSSION

This randomized trial demonstrates that adding structured isometric handgrip (IHG) training to a resistance-training program produced greater post-intervention gains in spirometric indices and functional exercise capacity than resistance training alone in ambulatory patients with GOLD stage II–III COPD. The magnitude of between-group separation at 8 weeks was most pronounced for FEV1 (MD 0.473 L; 95% CI 0.226 to 0.719; large standardized effect) and 6MWT distance (MD 31.36 m; 95% CI 15.24 to 47.48), while FVC showed a moderate effect (MD 0.374 L; 95% CI 0.060 to 0.688). These findings extend prior observational work linking peripheral muscle strength with pulmonary function and exercise capacity by providing interventional evidence that a brief, equipment-light peripheral isometric modality can act as a clinically meaningful adjunct to strengthening-based rehabilitation in COPD (18–21). Mechanistically, COPD-related activity intolerance and systemic inflammation are closely tied to limb muscle dysfunction, early fatigability, and impaired oxygen utilization, which can amplify ventilatory burden during daily tasks; interventions that improve peripheral muscle efficiency may therefore indirectly reduce the respiratory system's relative workload for a given activity, improving functional reserve and test performance (22). IHG training may additionally induce neuromuscular adaptations, improved motor unit recruitment efficiency, and peripheral circulatory benefits, which together can support higher sustainable walking outputs and improved ventilatory mechanics during exertion (23).

The observed superiority of the combined program is also consistent with the broader pulmonary rehabilitation literature in which multi-component exercise strategies tend to outperform single-modality programs for functional outcomes, particularly when both central (cardiorespiratory) limitations and peripheral muscle dysfunction are addressed in parallel (24,25). From an implementation perspective, IHG training is scalable and feasible for outpatient and low-resource settings because it can be performed seated, progressed using MVC-based prescription, and delivered with minimal space and supervision time compared with treadmill or cycle training. This feasibility addresses a key barrier in COPD care—low exercise adherence driven by dyspnea and fatigue—by offering an accessible entry-point activity that can be integrated into home-based routines while still preserving structured progression (26). The improvement in 6MWT in both arms supports the effectiveness of resistance training for functional capacity, but the larger gain in the combined arm suggests additive benefit from targeting upper-limb/forearm musculature via sustained isometrics, potentially enhancing overall muscular endurance and systemic conditioning beyond isolated strength improvements (24–26).

Several reporting and interpretation points require tightening to align with high-quality clinical trial standards. First, the manuscript must present one coherent sample size and recruitment flow across all sections: the “125 participants” statement conflicts with the trial dataset reported (N=48; n=24/group). All downstream text (including the abstract, methods, and results) should reflect the analyzed sample, ideally with a participant flow description (screened, excluded with reasons, randomized, completed, analyzed). Second, baseline comparability should be supported with appropriately reported inferential tests (or clearly stated descriptive-only baseline reporting) to avoid ambiguity. Third, although the p-values reported for several outcomes suggest strong statistical significance, the post-intervention FEV1/FVC between-group contrast shows uncertainty when expressed with a 95% confidence interval that crosses the null; this should be reconciled by confirming whether the analysis used post values, change scores, or a repeated-measures framework, and then reporting the exact model output consistently (including the correct p-value, df, and CI basis). Fourth, because multiple outcomes were tested (FEV1, FVC, ratio, 6MWT), the manuscript should pre-specify a primary endpoint and a multiplicity strategy (e.g., hierarchical testing or adjusted alpha) to prevent overstatement of significance, while still presenting effect sizes and confidence intervals to emphasize clinical interpretability over p-values alone (27). Finally, the discussion should more explicitly acknowledge that the single-center design, short follow-up, and lack of blinding may inflate observed effects, and future studies should evaluate sustainability, exacerbation-related outcomes, and broader GOLD severity strata using multicenter designs.

CONCLUSION

In ambulatory GOLD stage II–III COPD patients, an 8-week program combining isometric handgrip training with resistance exercise produced greater improvements in pulmonary function (FEV1 and FVC) and functional exercise capacity (6MWT) than resistance training alone, supporting IHG as a feasible, low-resource adjunct to strengthening-based pulmonary rehabilitation that may enhance clinically meaningful gains when integrated with conventional exercise prescriptions.

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