Study of cardiopulmonary rehabilitation versus cardiac rehabilitation in patients suffering from coronary artery diseases and chronic obstructive pulmonary disease

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Introduction Chronic obstructive pulmonary disease (COPD) and coronary artery disease are common treatable and preventable chronic diseases. Rehabilitation is now considered an important part of the long-term management in both diseases and includes exercise, education, and smoking cessation.

Patients and methods This study included 40 patients with COPD and coronary artery disease referred to the cardiac rehabilitation unit at Ain Shams University hospitals. Patients were assessed by clinical assessment, ECG, ECHO, modified Bruce protocol, spirometry, and St George's Respiratory Questionnaire (SGRQ). Then, patients were divided into two groups: a cardiac rehabilitation group and a cardiopulmonary rehabilitation group. All patients received 8–12 weeks of rehabilitation and were reassessed by spirometry, the modified Bruce protocol, and SGRQ.

Results Both groups improved in terms of spirometric parameters (forced expiratory volume in 1 s and forced expiratory volume in 1 s/forced vital capacity), SGRQ, and metabolic equivalents of tasks, but there was a statistically significant in resting heart rate in the cardiopulmonary rehabilitation group.

Conclusion The inclusion of upper limb exercise and inspiratory muscles training in pulmonary rehabilitation improves exercise tolerance in patients suffering from both COPD and coronary artery disease compared with cardiac rehabilitation alone.

Egypt J Bronchol 2019 13:6–11

Egyptian Journal of Bronchology 2019 13:6–11

Keywords: cardiac rehabilitation, chronic obstructive pulmonary disease, coronary artery disease, pulmonary rehabilitation

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Received 24 September 2017 **Accepted** 27 September 2017

Introduction

Chronic obstructive pulmonary disease (COPD) is a common preventable and treatable disease characterized by persistent respiratory symptoms and airflow limitation because of airway and/or alveolar abnormalities caused by significant exposure to noxious gases [1].

Muscle wasting is common in COPD patients, leading to muscle weakness and increased mortality [2]. It occurs because of imbalance between protein synthesis and degradation. Increased muscle protein breakdown is a key feature in muscle cachexia [3].

Atherosclerotic cardiovascular disease (CVD) is now the leading cause of death worldwide [4]. Risk factors for CVD include smoking, hypertension, obesity, and lack of physical activity [5]. Cardiac rehabilitation is associated with a reduction in both cardiac mortality (26–36%) and total mortality (13–26%) [6].

CVD is one of the leading causes of mortality in COPD cases. Smoking is significantly related to the development of COPD and CVD. In Egypt, the majority of deaths result from ischemic heart attacks and respiratory diseases caused by tobacco (http://global-health.healthgrove.com/l/97/Egypt#Overview&s=31ZG2j).

Pulmonary rehabilitation is an evidence-based, multidisciplinary, and comprehensive intervention for patients with chronic respiratory diseases who are symptomatic and often have disability because of decreased activity, social isolation, and depression [7–9].

Patients and methods

This prospective randomized case–control study was carried out on 40 patients recruited randomly from Ain Shams University hospitals (outpatient clinic) and were divided into two groups.

(1) Group 1 included 20 patients, who were recruited and subjected to clinical assessment in the form of assessment of history and physical examination,

 DOI: 10.4103/ejb.ejb_100_17

ECG, ECHO, spirometry to measure forced expiratory volume in 1 s (FEV_1) and FEV_1/forced vital capacity (FVC), St George's Respiratory Questionnaire (SGRQ), and cardiac rehabilitation.

(2) Group 2 included 20 patients, who were recruited and subjected to clinical assessment in the form of assessment of history and physical examination, ECG, ECHO, spirometry to measure FEV_1 and FEV_1/FVC, SGRQ, cardiac rehabilitation, and pulmonary rehabilitation.

In cardiac rehabilitation (including guideline-directed medical treatment plus treadmill exercise), each session lasted 30–60 min for the patients, of which 10 min included warm-up.

Moderate-intensity exercise training involved achieving a target heart rate of 40–60% of heart rate reserve calculated from a pre-exercise symptom limited stress test by the modified Bruce protocol and modulated by the Borg scale of rate of perceived exertion (RPE) to follow up the progression of exercise intensity; patients were exercised at an RPE of 11–13 in the absence of symptoms. Patient monitoring included RPE, recording of heart rate, blood pressure, respiratory rate (where indicated), and symptoms before and after activity.

The modified Bruce protocol [recording resting heart rate, maximum achieved heart rate, metabolic equivalents of task (METs) achieved, and duration of exercise] was used.

Bruce protocol (maximal table)

Stages	Minutes	km/h	METs
1	3	2.7	4
2	3	4.0	7
3	3	5.5	10
4	3	6.8	11
5	3	8.0	13
6	3	8.9	15
7	3	9.7	15

Total durations=21 min [10].

SGRQ is a questionnaire designed to measure health impairment in patients with asthma and COPD. It includes two parts: part 1: symptoms frequency and severity (best performance with 3-month and 12-month recall) and part 2: activities that are limited by breathlessness and impact on social functioning and psychological distress [11,12].

Education on smoking cessation and stress management was also incorporated into this phase in addition to exercise.

Pulmonary rehabilitation included additional upper limb unsupported endurance training for 10–30 min, with 10 min of warm-up before the exercise [13].

Exercises included the following:

(1) Flexion of the shoulder from 0 to 180° during inspiration, and then return to the initial position during expiration.
(2) Flexion of the shoulder from 0 to 180° during expiration, and return to the initial position during inspiration.
(3) Initial position: shoulder flexion at 90°, then horizontal abduction of the shoulder during inspiration, and return to the initial position during expiration (shoulder horizontal adduction).
(4) Initial position: shoulder flexion at 90°, then horizontal abduction of the shoulder during expiration, and return to the initial position during inspiration (shoulder horizontal adduction).

Initially, the exercises performed in this study were taught to participants and then they were asked to perform each of these exercises for a maximum time of 2 min. The exercises were interrupted if the individual felt dyspnea and/or muscle fatigue. Patients were instructed to inspire through the nose and expire with pursed-lip breathing during exercises. The four exercises were performed for at least 1 min each, with a time interval of 2 min between them [13]. Patients were monitored at least once weekly and followed up by telephone.

Both groups received 8–12 weeks of rehabilitation (two sessions/week), and were then reassessed using the modified Bruce protocol to measure exercise capacity in terms of estimated METs, duration of exercise, dyspnea score, SGRQ, and spirometry.

Our aim of the study was improvement of exercise tolerance in the form of improvement in METs, SGRQ, and improvement in spirometry in the form of FEV_1 and FEV_1/FVC.

Inclusion criteria

Men and women, 30–60 years old, with class B and class C COPD according to GOLD classification 2017, stable CHD less than or equal to The Canadian Cardiovascular Society grade 2, stable patients after a percutaneous coronary intervention or coronary artery bypass grafting, and patients with an ejection fraction more than 35% were included in the study.

Exclusion criteria

Patients with decompensated heart failure, class A and class D COPD, with acute infective exacerbation of

COPD, other respiratory disease, neuromuscular disease, disability that does not permit physical activity, patients who refused consent, and patients with unstable coronary syndromes and hemodynamically significant arrhythmias were excluded from the study.

Statistical analysis

(1) Descriptive statistics: to describe normally distributed quantitative data, we used mean and SD.
(2) Analytical statistics: to compare quantitative variables, we used an unpaired t test; also, qualitative variables were compared using the χ^2 test.

Results

In the prerehabilitation assessment, the FEV_1 of group 1 and group 2 were 38–70 (53.90±8.77) and 35–66 (50.34±8.27), respectively, without statistical significance. FEV_1/FVC in both groups were 52.3–68.5 (60.61±4.79) and 44–68.4 (60.54±6.41), with no statistical significance. Resting heart rate in the two groups ranged from 67 to 103 (82.75±9.56) and 65 to 100 (80.05±10.21), respectively, also with no statistical significance. METs of the two groups ranged from 3 to 10 (8.35±2.08) and 5 to 10 (8.15±1.81), respectively, with no statistical significance. SGRQ ranged from 56 to 98 (74.70±12.99) in group 1 and 50.2 to 100 (79.71±13.28) in group 2, with no statistical significance (Table 1).

In the postrehabilitation assessment, the FEV_1 of group 1 and group 2 were 41–76.3 (56.88±9.64) and 43–67 (55.76 ±6.23), respectively, without statistical significance. FEV_1/FVC in both groups were 56–71 (62.92±4.30) and 44–73 (64.95±6.44), with no statistical significance. METs of the two groups ranged from 7 to 13 (10.60±1.85) and 7 to 13 (10.45±1.76), respectively, with no statistical significance. SGRQ ranged from 52 to 95 (69.55±14.05) in group 1 and 40 to 88 (70.15±13.04) in group 2, with no statistical significance. Resting heart rate in the two groups ranged from 64 to 102 (78.40±9.87) and 62 to 87 (72.45±7.74), respectively, with statistical significance (Table 2).

In group 1, the prerehabilitation FEV_1 ranged from 38 to 70 (53.90±8.77) and the postrehabilitation FEV_1 was 41–76.3 (56.88±9.64), with high statistical significance. The FEV_1/FVC before and after rehabilitation ranged from 52.3 to 68.5 (60.61±4.79) and 56 to 71 (62.92±4.30), respectively, with high statistical significance. Resting heart rates before and after rehabilitation were 67–103 (82.75±9.56) and 64–102 (78.40±9.87), respectively, with high statistical significance. METs before and after rehabilitation were 3–10 (8.35±2.08) and 7–13 (10.60 ±1.85), respectively, with high statistical significance. In terms of SGRQ, prerehabilitation and postrehabilitation values were 56–98 (74.70±12.99) and 52–95 (69.55 ±14.05), with statistical significance (Table 3).

In group 2, FEV_1 before and after rehabilitation ranged from 35 to 66 (50.34±8.27) and 43 to 67 (55.76±6.23), with high statistical significance. FEV_1/FVC before and after rehabilitation were 44–68.4 (60.54±6.41) and 44–73 (64.95±6.44), with high statistical significance. Resting heart rate before and after rehabilitation was 65–100 (80.05±10.21) and 62–87 72 (45±7.74), with high statistical significance. METs before and after rehabilitation were 5–10 (8.15±1.81) and 7–13 (10.45

Table 1 Comparison between the cardiac rehabilitation group (group 1) and the cardiopulmonary rehabilitation group (group 2) in the prerehabilitation assessment in terms of forced expiratory volume in 1 s (in liter air), forced expiratory volume in 1 s/forced vital capacity (%), resting heart rate (bpm), metabolic equivalents of tasks, and the St George's Respiratory Questionnaire score

	Group 1 (*N*=20)	Group 2 (*N*=20)	Test value[a]	*P* value	Significance
FEV_1 pre					
Mean±SD	53.90±8.77	50.34±8.27	−1.323	0.194	NS
Range	38–70	35–66			
FEV_1/FVC pre					
Mean±SD	60.61±4.79	60.54±6.41	−0.041	0.967	NS
Range	52.3–68.5	44–68.4			
Resting heart rate pre					
Mean±SD	82.75±9.56	80.05±10.21	−0.863	0.393	NS
Range	67–103	65–100			
METs pre					
Mean±SD	8.35±2.08	8.15±1.81	−0.324	0.748	NS
Range	3–10	5–10			
		SGRQ pre			
Mean±SD	74.70±12.99	79.71±13.28	1.206	0.235	NS
Range	56–98	50.2–100			

FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HS, highly significant; MET, metabolic equivalents of task; S, significant; SGRQ, St George's Respiratory Questionnaire. [a]Chi-Square test.

Table 2 Comparison between the cardiac rehabilitation group (group 1) and the cardiopulmonary rehabilitation group (group 2) in the postrehabilitation assessment in terms of forced expiratory volume in 1 s (in liter air), forced expiratory volume in 1 s/forced vital capacity (%), resting heart rate (bpm), metabolic equivalents of tasks, and the St George's Respiratory Questionnaire score

	Group 1 (*N*=20)	Group 2 (*N*=20)	Test value[a]	*P* value	Significance
FEV_1 post					
Mean±SD	56.88±9.64	55.76±6.23	−0.436	0.665	NS
Range	41–76.3	43–67			
FEV_1/FVC post					
Mean±SD	62.92±4.30	64.95±6.44	1.173	0.248	NS
Range	56–71	44–73			
Resting heart rate post					
Mean±SD	78.40±9.87	72.45±7.74	−2.122	0.040	S
Range	64–102	62–87			
METs post					
Mean±SD	10.60±1.85	10.45±1.76	−0.263	0.794	NS
Range	7–13	7–13			
SGRQ post					
Mean±SD	69.55±14.05	70.15±13.04	0.140	0.889	NS
Range	52–95	40–88			

FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HS, highly significant; MET, metabolic equivalents of task; S, significant; SGRQ, St George's Respiratory Questionnaire.

Table 3 Comparison between prerehabilitation assessment and postrehabilitation assessment in the cardiac rehabilitation group (group 1) in terms of forced expiratory volume in 1 s (in liter air), forced expiratory volume in 1 s/forced vital capacity (%), resting heart rate (bpm), metabolic equivalents of tasks, and the St George's Respiratory Questionnaire score

	Group 1		Test value[a]	*P* value	Significance
	Pre	Post			
FEV_1					
Mean±SD	53.90±8.77	56.88±9.64	−6.938	0.000	HS
Range	38–70	41–76.3			
FEV_1/FVC					
Mean±SD	60.61±4.79	62.92±4.30	−5.843	0.000	HS
Range	52.3–68.5	56–71			
Resting heart rate					
Mean±SD	82.75±9.56	78.40±9.87	5.789	0.000	HS
Range	67–103	64–102			
METs					
Mean±SD	8.35±2.08	10.60±1.85	−7.336	0.000	HS
Range	3–10	7–13			
SGRQ					
Mean±SD	74.70±12.99	69.55±14.05	2.819	0.011	S
Range	56–98	52–95			

FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HS, highly significant; MET, metabolic equivalents of task; SGRQ, S, significant; St George's Respiratory Questionnaire.

±1.76), with high statistical significance. SGRQ before and after rehabilitation were 50.2–102 (79.71±13.28) and 40–88 (70.15±13.04), with high statistical significance (Table 4).

Discussion

In our study, group 1 prerehabilitation FEV_1 ranged from 38 to 70 (53.90±8.77) and postrehabilitation FEV_1 was 41–76.3 (56.88±9.64), with high statistical significance. The FEV_1/FVC before and after rehabilitation ranged from 52.3 to 68.5 (60.61 ±4.79) and 56 to 71 (62.92±4.30), respectively, with high statistical significance.

This was in partial agreement with Kaminsky *et al.* [15], who showed that lung functions improved in association with cardiac rehabilitation in participants with a baseline BMI 30 kg/m^2 or higher.

In our study, METs in group 1 before and after rehabilitation were 3–10 (8.35±2.08) and 7–13 (10.60 ±1.85), respectively, with high statistical significance.

In this study, in terms of SGRQ in group 1, prerehabilitation and postrehabilitation values were 56–98 (74.70±12.99) and 52–95 (69.55±14.05), with statistical significance.

Table 4 Comparison between prerehabilitation assessment and postrehabilitation assessment in the cardiopulmonary rehabilitation group (group 2) in terms of forced expiratory volume in 1 s (in liter air), forced expiratory volume in 1 s/forced vital capacity (%), resting heart rate (bpm), metabolic equivalents of tasks, and the St George's Respiratory Questionnaire score

	Group 2		Test value[a]	*P* value	Significance
	Pre	Post			
FEV_1					
Mean±SD	50.34±8.27	55.76±6.23	−4.055	0.001	HS
Range	35–66	43–67			
FEV_1/FVC					
Mean±SD	60.54±6.41	64.95±6.44	−7.018	0.000	HS
Range	44–68.4	44–73			
Resting heart rate					
Mean±SD	80.05±10.21	72.45±7.74	8.970	0.000	HS
Range	65–100	62–87			
METs					
Mean±SD	8.15±1.81	10.45±1.76	−4.351	0.000	HS
Range	5–10	7–13			
SGRQ					
Mean±SD	79.71±13.28	70.15±13.04	9.510	0.000	HS
Range	50.2–102	40–88			

FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; HS, highly significant; MET, metabolic equivalents of task; S, significant; SGRQ, St George's Respiratory Questionnaire.

This was consistent with the Michigan society for cardiovascular and rehabilitation report as they reported an improvement in quality of life and MET in their participants [15].

In our study, the resting heart rate in group 1 before and after rehabilitation ranged from 56 to 98 (74.70 ±12.99) and 52 to 95 (69.55±14.05), respectively, with high statistical significance.

This was consistent with Almeida and Araújo [16], who studied the effect of aerobic exercise on heart rate and found that it causes a lower resting heart rate; and this may be because of higher parasympathetic activity.

In group 2, there was a highly statistically significant change in FEV_1 before and after rehabilitation, ranging from 35 to 66 (50.34±8.27) and 43 to 67 (55.76±6.23), respectively. FEV_1/FVC before and after rehabilitation was 44–68.4 (60.54±6.41) and 44–73 (64.95±6.44), with high statistical significance. METs before and after rehabilitation were 5–10 (8.15±1.81) and 7–13 (10.45 ±1.76), with high statistical significance. SGRQ before and after rehabilitation were 50.2–102 (79.71±13.28) and 40–88 (70.15±13.04), with high statistical significance.

This was in partial agreement with Naglaa *et al.* [17]. There was a statistically significant improvement in FEV_1 and FVC in patients who had received pulmonary rehabilitation. Also, there was a significant improvement in exercise tolerance in the form of improvement in 6-min walk distance. There was a statistically significant improvement in the MRC dyspnea score (P=0.019) after incentive spirometry and respiratory exercises.Also, Barakat *et al.* [18] showed that patients' involvement in a rehabilitation program led to a significant improvement in quality of life as assessed by the SGRQ.

Egan *et al.* [19] reported that 8 week pulmonary rehabilitation program led to significant improvements in exercise field tests (incremental shuttle walk test and 6-min walk test), inspiratory muscle strength (PiMax), and quality-of-life scores.

Another study by Mahler and Daubenspeck [20] was consistent with this as it found that inspiratory muscle training resulted in a considerable increase in respiratory muscle function and a marked decrease in dyspnea; this is in agreement with the concept that an increase in the strength of inspiratory muscles can induce a decrease in dyspnea.

Some authors suggest that inspiratory muscles in COPD patients are already adapted to work load and do not show any adaptation in response to training. Despite this, after inspiratory muscle training (IMT), a marked increase in the proportion of type I fibers (by 38%) and in the size of type II fibers (by 21%) of the external intercostal muscles have been found [21]. These structural changes mostly represent adaptive changes in inspiratory muscle structure during IMT.

Also, this was in agreement with a meta-analysis carried out by Bendstrup *et al.* and co-workers [22], where the 6-min walk distance increased.

Kakizaki *et al.* [21] showed an increase in FVC by stretching respiratory muscles. The FVC is affected by elastic recoil and respiratory muscle fitness.

Conclusion

The inclusion of upper limb exercise and inspiratory muscles training in pulmonary rehabilitation improves exercise tolerance in patients suffering from both COPD and coronary artery disease compared with cardiac rehabilitation alone.

Acknowledgements

First and foremost, I feel always indebted to ALLAH, the Most Kind and Most Merciful. I'd like to express my respectful thanks and profound gratitude to Professor/Yasser Mostafa Mohamed, Professor of Chest Diseases, Ain Shams University for his keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work. I am also delighted to express my deepest gratitude and thanks to Doctor/Hala Mohamed Salem, Assist. Professor of chest diseases, Ain Shams University, for her kind care, continuous supervision, valuable instructions, constant help and great assistance throughout this work. I am deeply thankful to Doctor/Hazem Mohamed Khorshid, Lecturer of Cardiology, Ain Shams University, for his great help, active participation and guidance. My sincere thanks also goes to Dr. Riham Hazem Raafat, Lecturer of chest diseases, Ain shams university, for her advices, ideas and guidance that provided to be a landmark effort towards the success of my research. I would like to express my hearty thanks to all my family for their support till this work was completed. Last but not least my sincere thanks and appreciation to all patients participated in this study. Karim Hossam El-Din Abdel Fattah Abdel Aziz.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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