Chapter

Exercise Training and Pulmonary Rehabilitation in COPD

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Abstract

Systemic inflammation and deconditioning syndrome lead to loss of structural and function of body muscle, particularly in extremity muscle. Longer period of inactivity due to dyspnea worsen the destruction of muscle. Regular and gradually increase exercise training as part of pulmonary rehabilitation (PR) can improve the function of essential muscles in doing daily life so stable Chronic Obstructive Pulmonary Disease (COPD) patient can maintenance their daily activities with minimal limitations. Pulmonary rehabilitation consists of exercise training, nutritional support, smoking cessation, and self-management of COPD. The prescription of exercise training is mandatory. Assessment of clinical condition to adjust the type of training, duration, frequency, and intensity of training must be completed before beginning the training session. Regular and gradually increased training gives significant impact in improving lung function, dyspnea scale, and quality of life in patient with stable COPD. However, in this covid era, the restriction of hospital attending PR was significantly affect PR program. As immunocompromised population, COPD patient have higher risk for COVID19 infection and develops more severe complications compare with normal population. So, the modified supervised and unsupervised training was needed to revise the classic type of PR. Tele-rehabilitation with teleconference, phone calls, and interactive web based PR can be the good alternative in decreasing hospital admission and improving quality of life in patient with COPD.

Keywords: Pulmonary rehabilitation, exercise training, COPD, tele-rehabilitation, covid-era

1. Introduction

Dyspnea is the main symptom of Chronic Obstructive Pulmonary Disease (COPD) that correlates with the limitation of daily activity [1, 2], anxiety and other psychological impacts [3, 4], low quality of life [5], and reduced survival rate [6]. Dyspnea can manifest across the degree of pulmonary obstruction. Either patients with moderate or severe obstruction can experience dyspnea in their daily activities [7]. All these facts cause dyspnea and exercise tolerance becoming the main focus in COPD management in a few guidelines [8, 9].

Besides the pharmacological approach, pulmonary rehabilitation (PR) is considered an important part of comprehensive COPD treatment, particularly in group B-D [10]. Almost all types of pulmonary rehabilitation have a positive impact on the dyspnea scale of patients with COPD. Six-week of pulmonary rehabilitation was given to the end-stage of COPD outpatients and provide a significant improvement of dyspnea scale using a visual analog scale [11]. A meta-analysis study also suggests including upper extremity exercise in pulmonary rehabilitation because it can relieve dyspnea in COPD, although few studies showed the insignificant difference of Borg scale after the training [12]. A study that compares endurance training, combined endurance and strength training, and pharmacological alone showed the improvement of dyspnea in endurance and combined training, but not in a pharmacological alone group. It stated that strength training gives an additional impact on muscle force, but not different from endurance training alone in health status [13]. This is in line with the previous author's study that showed 4 weeks of upper extremity exercise without strength training had demonstrated the improvement of dyspnea scale using the mMRC scale [14].

On the other side, an intervention study with 6 weeks of cardiopulmonary exercise showed an insignificant improvement of dyspnea scale measured with 0–10 Category Ratio (CR) in COPD patients [15]. But as general, a review article that compiles few meta-analyses, randomized controlled study, reviews, and the clinical trial showed that pulmonary rehabilitation gives positive impacts in COPD patients according to functional outcomes, dyspnea scale, and quality of life [16]. Different results might be caused by different dyspnea scales used in the various study. But according to GOLD, the Borg scale and mMRC scale were recommended to measure the dyspnea scale in COPD patients (*Global Initiative for Chronic Obstructive Lung Disease*, 2019).

Breathing training as part of PR can improve regional ventilation and gas exchange and respiratory muscle function that later improves the exercise tolerance and quality of life of patients [17]. Breathing training includes diaphragm breathing, pursed-lip breathing, relaxation technique, and body position [18]. In a study, diaphragm breathing alone and the combination of diaphragm breathing and pursed-lip breathing can reduce the asynchrony of inspiration-expiration ratio and increase lung volume [19]. A study also stated the combination of upper limb training and pursed-lip breathing can decrease dyspnea, improve exercise capacity, and quality of life in patients with stable COPD [14]. Diaphragm breathing (DB) itself improves breathing patterns by coordinating the rib cage muscles and abdominal wall, reduce the activity of the accessory muscle, and lead to improving exercise tolerance [20].

2. Deconditioning syndrome

Decondition syndrome refers to the change in the structure and function of body muscle due to inactivity. This syndrome usually occurred in chronic cardiovascular and lung disease, including Chronic Obstructive Pulmonary Disease (COPD) [21, 22]. This change involved muscle, cardiac, lung, and vascular-related to the history of the disease [23]. This syndrome consisted of three steps:

1. Mild deconditioning: this condition affects normal exercise in which a patient will experience dyspnea and fatigue after doing some exercise include cycling, biking, and swimming.

2. Moderate deconditioning: this condition affects daily activities including walking, shopping, and lifting some goods.

3. Severe conditioning: in this condition, the patient cannot do any activities and just laying on the hospital bed.

Decondition syndrome is a vicious cycle that occurred progressively. The longer the period of inactivity, the more severe the deconditioning will be, and the longer it will take to return to your previous level of functioning [21].

Generally, three basic mechanisms contribute to deconditioning syndrome in chronic pulmonary disease. There is an imbalance between oxygen distributed along with the systemic and respiratory muscles and the amount of oxygen served, muscle dysfunctions include a structural and functional change in extremity and respiratory muscle, and imbalance between ventilation capacity and the amount of ventilation needed for running daily activities [24–26].

The disturbance of exercise capacity may result in systemic manifestation rather than pulmonary disease. Systemic inflammation, hypoxia, and deconditioning syndrome are caused by muscle atrophy and loss of muscle functions [26]. Muscle atrophy occurs when there is an imbalance of protein synthesis due to lower testosterone levels [21, 22] and protein degradation. Increased levels of ubiquitin and TNF-α was seen in several studies [26, 27]. Further, malnutrition, chronic hypoxia, oxidative stress will increase systemic inflammation and muscle disturbance [26].

3. Pulmonary rehabilitation

Pulmonary rehabilitation is a substantial part of comprehensive treatment in COPD in every stage. According to GOLD 2021, pulmonary rehabilitation is recommended in stage B-D of stable COPD. Pulmonary rehabilitation includes exercise training, smoking cessation, nutrition, and education for self-management intervention [28]. Pulmonary rehabilitation should be offered to patients with COPD to improve dyspnoea and health status by a clinically important amount. Besides, pulmonary rehabilitation also alleviates psychological disturbance results in the long-term effect of chronic pulmonary disease.

1. Exercise training

   Exercise training is the main part of pulmonary rehabilitation. According to GOLD 2020, regular exercise training can improve shortness of breath, exercise tolerance, and quality of life status [29]. Exercise training includes endurance/aerobic training, strength training, and inspiratory muscle training. According to GOLD 2021, the combination of these training gives better outcomes compared with the method alone [28].

2. Nutritional support

   In COPD patients, the high level of katabolic cytokines contributed to malnutrition [30]. A high level of IL-6, IL-8, TNF-α showed in COPD patients and their levels have a role as predictors of worse outcomes in COPD [26, 30–32]. Also, high broadcasting of leptin in COPD patient play roles in decreased appetite consequently in decreased muscle mass and functions [33, 34]. Twenty-five to forty percent of COPD patients experienced malnutrition and 25% of them has moderate to severe malnutrition with low fatty fat mass [35].

   The nutritional intervention showed a significant increase in muscle mass and function leads to exercise tolerance improvement. Antioxidant properties in vegetables and fruit may increase the antioxidant resulted in decreasing systemic inflammation [36]. Besides, high fat with low carbohydrate food also showed the improvement of pulmonary function in stable COPD patients [37]. So, after the exercise training intervention, nutritional support must be considered as a substantial part of pulmonary rehabilitation.

3. Self-care management of COPD

   Individual management of COPD is an important part of pulmonary rehabilitation. We have to educate the patient about steps of smoking cessation, an inhaler used, recognition of exacerbation, and when to admit to the hospital. The patient should be known his condition, including the risk and complications of his disease, and the risk of not taking medicine regularly. They should be informed about the factors contributing to exacerbation and how to handle them. In this session, physicians must collaborate not only with the patient but also with his patient's family. Motivate the patient to stop smoking or even changed his job if it contributed to the uncontrolled symptom of COPD. Education also involved how to convincing the patient for taking the exercise training regularly and continue attending the session of exercise training by himself after discharge from the hospital [28].

4. Exercise training preparation

Before beginning the session of training, we must assess the baseline condition of the patient to prepare the individual dose of training.

Following assessment must be undergone for every stable COPD patient [28]:

1. A detailed history and physical examination of the patient. This must be important to rule out the group of the patient and the risk for exacerbation.

2. Measurement of airway obstruction using spirometer before and after bronchodilator

3. Assessment of exercise capacity using the six-minute walking test. In the available facilities, cycle ergometer and treadmill exercise can be used to measure the physiological variables that impact the exercise capacity, including maximum oxygen consumption, maximum heart rate, and maximum work performed [28].

4. Health status and the impact of breathlessness in doing exercise

5. Assessing the respiratory and limb muscle in patients with muscle wasting

6. Individual patient goals and expectations

4.1 Prescription of exercise training in COPD

There are few parameters must be considered to prescribe an exercise training in COPD patient. There was no guideline plainly stated that exercise training cannot be done in an exacerbated state. The frequency, intensity, time, and type of exercise training, abbreviate by FITT must be reviewed before beginning the session of training. And these parameters also correlated with outcomes [29].

According to one systematic review, there was dose-related training and outcomes. High-intensity training tends to have more significance to exercise tolerance measured by maximal heart rate and oxygen uptake in exercise (VO2max) [38]. But the problem is the practical and economic reasons, the duration of lasting longer than 6–8 weeks of supervised training considered to highly economic demands [39] considered to be significant. According to consensus, exercise training is arranged for 6–12 weeks duration with two to three supervised sessions per week with 60–90 minutes for 1 session [39–42].

4.2 Frequency of supervised training

1. Exercise training programs should be two-five times a week [39, 43]

2. Supervised of pulmonary rehabilitation should be minimum 2 times a week, other sessions can be undergone at home without supervised by physicians or therapist

4.3 Duration of supervised training

1. 30 minutes of physical activity gives a positive impact on a healthy subject [39, 43]

2. 6–12 weeks of training are recommended in all types of exercise training.

3. Long term training (more than six months of training) for outpatient give a more significant impact on exercise tolerance, exacerbation events, and quality of life [44]

4. Intermittent exercise can be arranged for a patient who cannot tolerate continuous training. In initial training, moderate to severe COPD tend to have only a few minutes of training and we can increase it gradually by about 5–10 minutes every 1–2 weeks [45].

4.4 Intensity of training

1. 50–80% maximal workload must be arranged in exercise. According to American Sports Medicine, it is divided into [45]:

   Light intensity: 30–40% peak work rate.

   Vigorous-intensity: 60–80% peak work rate

2. American Thoracic Society and European Respiratory Society recommend initial training with >60% maximal work rate [40].

3. Workload defined as VO2 max and maximum heart rate with the formula is 220-age

4. Targeted of intensity is 60–70% RM (Repetition Maximum) or 100% of 8–12 RM

5. American Association of Cardiovascular and Pulmonary Rehabilitation (AACRP) recommended initiating the training with light intensity and gradually increased it until reaches the maximal target [46].

4.5 Type of training

1. Endurance training

   Endurance training is the most common training prescribed for severe COPD. Endurance training can improve aerobic exercise capacity so the patient can do his daily activities more comfortably without shortness of breath [47]. Endurance training also can improve peripheral muscle function in severe COPD patients [48]. But according to the Casaburi study, endurance training with high intensity has a greater impact compared with low intensity [22]. But this intensity can be gradually increased in line with the patient's condition. Walking and cycling are the most recommended endurance training for exercising the lower limb [49]. Fatigue in large muscles in the thigh including quadriceps femur muscle and hamstring muscle often occurs at the beginning of the training [50, 51]. But, it will decrease after a few sessions of training, so a gradually increased dose is needed in the training arrangement. Further, walking on the ground give a more significant impact in improving the walking capacity in severe COPD patients [49]. Upper extremity exercise involved biceps, triceps, deltoid, and accessory respiratory muscles including latissimus dorsi muscle and pectoralis mayor should be trained to give additional effect in alleviating shortness of breath [14].

A six-minutes walking test (6-MWT) is the most recommended examination for assessing the impact of endurance training [39]. Due to its economic aspect, easy to do, low side effect, 6-mwt is recommended in every guideline [39, 40]. But, a cardiopulmonary exercise test (CPET) has been a gold standard in assessing exercise capacity. We can measure cardiorespiratory performance and VO2 max [45]. However, this method is expensive and needs more equipment so it cannot be done performed in every facility, particularly in healthcare facilities without a standard pulmonary rehabilitation center. Other measures can sit to stand tests (STST), incremental shuttle walking test (ISWT), and endurance shuttle walking test (ESWT) [49].

2. Strength training

Disturbance of muscle structure and function in COPD patients has been discussed before. Strength training or resistance training give a more significant impact on muscle enhancement in COPD patients [40, 42, 47]. Its impact in peripheral and large muscle alleviate dyspnea and improving the activity which gives more effort including climbing the stairs, standing, and arm elevation [47]. So, if combining with endurance training, a systematic review shows a greater impact on the quality of life of a patient with COPD [52].

Frequency, intensity, repetition, and type of strength training contribute to the impact of training. Large individual variations further affect the quality of training. Six until twelve repetitions about 15–45 minutes for 2–3 days recommended in strength training in some guidelines [41]. The patient can take a break when begin to experience dyspnea. A short bronchodilator should be given immediately with oxygen supplementation.

3. Inspiratory muscle training

Different from endurance and strength training, inspiratory muscle training focused on the enhancement of the diaphragm [17]. In COPD, the emphysema process made the disturbance of the elasticity of the diaphragm to make contraction and relaxation, showed in the hyperinflated lung, narrowed and more vertical heart, and flattened diaphragm in radiographic appearance.

Inspiratory muscle training improves diaphragm muscle strength and endurance so it can reduce dyspnea [47]. This training is often combined with upper and lower body training for maximizing the effect of pulmonary rehabilitation in stable COPD.

This training was recommended in 5–7 days per week with a duration 7x2 minutes interval approach and 1-minute rest between intervals. The total duration of this training is 15–20 minutes for each day [53, 54].

4.6 Variation of exercise training

There is no absolute content of exercise training in COPD. We can design our method according to our facilities and human resources. In our setting, we have arranged a few methods of exercise training and showed a significant impact on breathing scale and quality of life.

Below is one of the type of exercise training in our setting. The procedures include:

After taken the baseline data, patients in the intervention group were scheduled for the training program. The training program was held twice a week for four weeks. The procedures of the study were the following:

1. Heating. Participants were given infrared radiation for 10 minutes in their chest to warm the chest muscle and facilitate sputum expectorant.

2. Chest therapy. In this session, the chest muscle was massaged, stretched, and then vibrated to facilitate the sputum expectorant.

3. Upper limb endurance training with simple gymnastics using the neck, shoulder, and arm. Along with these procedures, pursed-lip breathing was performed to facilitate breathing training

4. Upper limb strength training using dumbbell with personalized weight lifting. First, we examined the maximal weight lifting in five repetitions. For the 1st week of practice, we used 60% of maximal weight lifting (kg) and then increased progressively every week.

Upper limb endurance training in our setting consisted of few 10 moves (**Figures 1–10**):

Figure 1.
Pursed lip breathing with exhaling while tilting your head towards your shoulder.

Figure 2.
Bird-like pattern with inhaling while body straightening, exhale while bending forward to the bottom.

Figure 3.
No-way pattern with pursed-lip breathing, seeing movement to left and right alternately.

Figure 4.
Shoulder shrug with pursed-lip breathing.

Figure 5.
Fan-like movement with pursed-lip breathing, hands are bent together, then turn right and left.

Figure 6.
Chicken cuckoo like movements with rotating the shoulder with hands bent at the shoulder.

Figure 7.
Vampire-like movement, hands straight forward while inhaling, then rotating the body to the right, left, and forwards while exhaling.

5. Supported vs. unsupported pulmonary rehabilitation

Long-term PR tends to gradually decrease over a while [55]. Many circumstances contribute to discontinuous training after a short period of intensive PR, including lack of motivation, support from friends and families, disease progressivity, and distance from health facilities [56]. For the last reason, home-based PR might become

Figure 8.
Calling movement, the hand is lifted, then touched downwards, in the opposite direction.

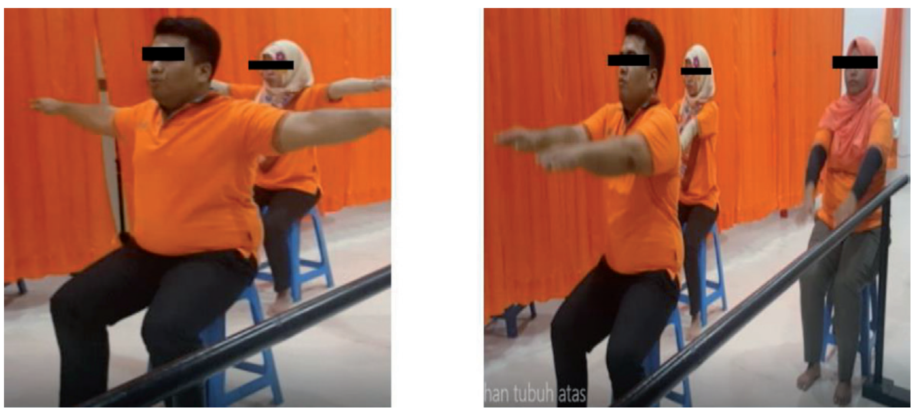

Figure 9.
Butterfly-like pattern, hands stretched straight forward then hands stretch.

Figure 10.
Cooling down with pursed lip breathing.

an alternative. According to Swerts et al., the continuation of 12 weeks of supervised training maintained 1-year of walking ability in stable COPD patients [57]. Further, Ries et al. suggested a year of home-based PR with once a month of supervised training at health facilities to control the procedure and the impact of PR in the stable COPD patient. Ries et al. also evaluate the impact of maintenance PR by telephone for

1 year after a short period of supervised training in health care facilities. This study revealed that during the first 12 months, there were improvements in exercise tolerance and health status in patients undergone telephone supervised training and once in a month controlled training at health facilities in chronic pulmonary disease [58].

There were no definite guidelines that recommend the duration of supported and unsupported PR. But studies showed that 8–12 weeks of supported PR followed by 12–24 months of giving substantial effect in exercise tolerance and quality of life in a patient with COPD [56]. In another study, Guel et al. showed that 6 months of intensive supervised training followed by 6 months of once-in-week supervised exercise training give an improvement of dyspnea scale and quality of life compared with the control group which no additional PR after intensive supervised training [59]. Another study also showed the reduction of exacerbation with hospital admission after retreatment PR in outpatient with stable chronic pulmonary disease who has stopped PR for 1 year, although there was no difference in exercise tolerance and quality of life compare with the control group [60].

There are few modifications for unsupported PR. We can monitor once a week or once a month to control the correct procedure and the impact that might be occurred, both positive and negative impact.

More than 50% of the participant who attends long term PR was a loss to follow up. Both once in a month or once in three months of supervised training with the rest session is home-based PR showed no significant difference in the 1-year loss to follow up [61]. Whereas, the impact of intensive and supervised PR for 8–12 weeks will disappear after 1 year [56]. So, the long-term supported PR is needed to improve the exercise capacity and dyspnea tolerance in stable COPD patients to maintain their daily life.

6. Tele-rehabilitation in Covid19 era

In this pandemic era, pulmonary rehabilitation was significantly affected. Strict regulation to decrease hospital admission in people with COPD gives a significant impact on stable COPD patients who attend regular pulmonary rehabilitation in the hospital [62]. Further, COPD patients were susceptible to infections due to lack of immunity and chronic inflammatory state. So, a new era of pulmonary rehabilitation was needed to reform the classic pulmonary rehabilitation.

Theoretically, teleconference PR will enhance the adherence to attending PR sessions in stable COPD patients, particularly patients whose address was far from the PR center. But, data showed that there was no significant difference in the impact of a patient who attends teleconference PR compare with conventional PR [62]. Few factors contribute to the poor adherence to PR programs. They are including availability, accessibility, and attrition [63]. The alternative method including home-based supervision, interactive web-based PR, videoconference with telehealth can be implicated in the new settings of PR [64–66].

Teleconference PR or telerehabilitation has been discussed since early 2000. Tele-rehabilitation was the new concept of PR where the patient was being at home and used communication and information to provide PR [67]. This was promising alternative ways in patients whose addresses were far from the PR center and in this covid era. On the other side, this alternative way also has severe limitations including short duration of intervention, small patient number, communication error, limitation of technology facilities, and poor adherence of several components of PR [65]. Specific guidelines of telerehabilitation must be accomplished to achieve maximal impact on the patient. This needs the coordination of several aspects including administration, organization, physical trainee, physicians, and government [67].

In telerehabilitation particularly in chronic respiratory disease, few modules must be carried out. Inhaler used training, smoking cessation, dietary and self-management advice, physical exercise, and psychological support must be scheduled formally through phone calls or video conference with a certain physiotherapist, dietician, and pulmonologist [66, 68]. There were no guidelines regulate the definite duration, frequency, and type of training in telerehabilitation. Bhatt study arranges 36 exercise sessions in 12 weeks consists of a combination of stretching and breathing training for warming up, aerobic exercise including ergometer bicycles until maximum heart rate was achieved (60–80% maximal HR). Resistance training used resistance band was performed with a video tutorial that was given before. Also, breathing training including basic yoga training, diaphragm breathing training, paced-training, and pursed-lip breathing was carried out in stable COPD patients. After few sessions, an educational video conference was performed consisted of smoking cessation, psychological support, appropriate inhaler technique, disease education, monitoring, and reporting exacerbation [66]. Another study performed 144 sessions for 12 months with 2 months of initial training PR programs in the PR center to educate the patients to use the modal facilities and how to monitor the function of each piece of equipment. In the next 10 months, patients were undergone self-exercise training with remote monitoring. Educational programs including dietary, self-management, and psychological support were performed in a video conference. Strict monitoring of vital signs during training particularly heart rate and oxygen saturation were recorded and send to physicians after the end of each training session [68]. After all the training session, several parameters can be measured to evaluate the impact of the teleconference, including modified Medical Research Council dyspnoea scale (mMRC), COPD assessment questionnaire (CAT), St. George's Respiratory Questionnaire (SGRQ), Hospital Anxiety and Depression Scale (HADS), spirometer, pedometer, and hospitalization event, length of stay, and Emergency Room visits [66, 68].

Few studies have proved that telerehabilitation has benefits to stable COPD patients. Bhatt's study showed that early telerehabilitation after the patient was discharged from the hospital due to exacerbation has reduced 30 days of re-admission in hospital from all causes of exacerbation [66]. Vasiloupoulou's study also stated that home-based maintenance telerehabilitation was the same effect as hospital-based PR in reducing the risk of acute exacerbation and hospitalization [68].

New South Wales Health of Ministry has arranged telehealth pulmonology rehabilitation in the covid19 era. It consisted of four main components including patient assessment by phone calls and teleconference, home-based individual exercise program by videoconferencing, patient education, and the re-assessment of the patient after completed all the training programs [69].

1. Patient assessment

   Phone calls and video conferences can be conducted in the patient assessment sessions. It is included general medical history contains respiratory symptoms, social history, the course of the disease, history of hospitalization, medication, vaccinations, and smoking history. Symptoms were evaluated by Borg scale, mMRC, SGRQ, CAT, HADS, and CRQ. Objective measurement must be carried out including height, weight, oxygen saturation, blood pressure, and heart rate. Further, lower limb strength can be measured by 5 minutes sit to stand test (5STS) while lower limb endurance is measured by a 1-minute sit to stand test (1STS).

2. Exercise programs

   There are few types of telehealth PR. NSW Health recommends lower limb endurance training using the walking method while the endurance training by

5STS and squats-stand. Upper limb training used light hand weights for endurance training and a resistance band for strength training.

a. Duration: lower limb endurance (start 10–15 minutes and continue in 30 minutes); upper limb endurance (10 mins); lower limb strength (10 mins); upper limb strength (10 mins)

b. Intensity: moderate to severe

c. Frequency: 2 days in PR center and other 2 days at home

d. Length of programs: 8 weeks

e. Type: continues, interval, and intermittent

3. Patient education

   a. Description about lung disease

   b. The benefit of exercise programs and physical activity

   c. Symptom evaluation and management

   d. Inhaler technique

   e. Smoking cessation

   f. Nutrition

   g. Psychological support

4. Re-assessment

7. Conclusions

Last, COPD patient was advised to follow the pulmonary rehabilitation to do exercise training by themselves. Pulmonary rehabilitation is comprehensive management and evaluation that involved a few basic knowledge including nutrition, psychologist, physiotherapist, pulmonologist, and other specialist doctors depend on the patient's condition and co-morbid.

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