Respiratory muscle training in chronic obstructive pulmonary disease

Antrenamentul mușchilor respiratori în boala pulmonară obstructivă cronică

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Abstract

Chronic obstructive pulmonary disease (COPD) associates weakness and loss of muscle mass as an extra-respiratory complication. This muscle wasting is related in COPD to systemic inflammation, chronic hypoxia, deconditioning, malnutrition, disorder in ventilation mechanism, or steroid myopathy. Pulmonary rehabilitation (PR) is a multidisciplinary program meant to improve physical, psychological and social performances in COPD patients. Respiratory muscle training (RMT) is a specific method which provides significant benefits inside PR programs. It may improve both respiratory muscle strength and endurance. RMT will start in special rehabilitation centers upon recommended protocols under supervision and it will be continued for long-term at home. Several studies showed that RMT decreases dyspnea, enhances the effort capacity (according to the 6-minute walk test) and improves the quality of life in COPD patients.
Keywords: ***respiratory muscle training, pulmonary rehabilitation, COPD***

Rezumat

Boala pulmonară cronică obstructivă (BPOC) asociază printre complicațiile sale extrarespiratorii slăbiciunea și pierderea masei musculare. Această afectare musculară apărută în BPOC este secundară inflamației sistemice, hipoxiei cronice, decondiționării, malnutriției, tulburării mecanismului de ventilație sau steroizilor. Reabilitarea pulmonară (RP) este un program multidisciplinar menit să îmbunătățească performanțele fizice, psihologice și sociale ale pacienților cu BPOC. Antrenamentul musculaturii respiratorii (AMR) este o metodă specifică ce oferă beneficii semnificative în cadrul programelor de RP și poate îmbunătăți atât forța musculară, cât și rezistența. AMR va fi inițiat în centre speciale de reabilitare, pe baza protocoalelor recomandate, sub supraveghere, și va fi continuat pe termen lung la domiciliu. Mai multe studii au arătat că AMR scade dispneea, crește capacitatea de efort (evaluată prin testul de mers de 6 minute) și îmbunătățește calitatea vieții la pacienții cu BPOC.
Cuvinte-cheie: ***antrenament musculatură respiratorie, reabilitare pulmonară, BPOC***

Introduction

Chronic obstructive pulmonary disease (COPD) is a common disease which manifests by progressive airflow limitation determined by airway changes induced by noxious particles (cigarette smoke, gases)[1].

The most important symptoms in COPD patients are dyspnea, chronic cough and physical activity diminution produced by airflow limitation, mucous glands hypersecretion, air trapping and static hyperinflation. Dyspnea worsens during effort by additional dynamic hyperinflation. Consecutively, the patients reduce their level of daily activities (deconditioning). Physical inactivity leads to more dyspnea and reduces the effort tolerance, creating a vicious cycle.

COPD patients may experience respiratory muscle weakness and even decrease in muscular mass as an extra-respiratory complication related to several associated conditions: systemic inflammation and oxidative stress, hypoxia, hypercapnia, lactic acidosis, muscle deconditioning, dysfunction in ventilation mechanism, malnutrition or steroid myopathy[2-6].

Muscle fatigue and muscle loss are the result of structural and functional changes[7-9]. Structural muscle abnormalities are characterized by dystrophy and muscle weakness responsible mostly with tiredness to exercise. Histochemical changes found were a decrease in type I and IIa muscle fibers (fibers with oxidative potential and greater resistance to fatigue) and an increase in type IIb fibers (susceptible to fatigue), sarcopenia and a reduction of intramuscular capillaries density[9-11]. Functional abnormalities consist in a reduction of muscular oxidative and glycolytic capacity by decreasing the oxidative enzymes and increasing LDH with lactic acid excess. There will be an early lactic acidosis in the skeletal muscle with regression of the aerobic pathway and advantage from the anaerobic glycolysis. This produces a disturbance in ATP metabolism with loss of energy-rich molecules[12].

During exercise, respiratory rate is much increased in relation with hyperinflation and low inspiratory capacity. Due to thoracic distension, COPD patients can't increase tidal volume, so they are increasing the respiratory rate. Respiratory muscles (diaphragm) must generate a very high intrathoracic pressure. Consecutively, diaphragm dysfunction appears causing the reduction in the pressure-generating capacity of the diaphragm. Cellular and molecular alterations have been described, especially loss in myosin heavy chains and high levels of protein derivative from muscle protein degradation[8]. Also the diaphragm adapts by decreasing the length of the sarcoma and increasing the mitochondrial concentration[13].

Inflammation and hypoxia lead to the emergence of the "reactive nitrogen species" that causes oxidative stress and disorders in muscle contractility. Impaired contractile proteins reduce calcium sensitivity and the generated force of the diaphragm. Muscle fatigue will arise even in patients with mild to moderate COPD(8-10). This may be reversible by hypoxia correction and physical training exercises(8,9).

Respiratory muscle damage has clinical manifestations: dyspnea, fatigue, and effort limitation, the development of hypercapnic respiratory failure, while expiratory muscles are linked to the effectiveness of cough(14).

Targeted respiratory muscle training (RMT) can be used as a specific technique in the pulmonary rehabilitation (PR) programs, especially in COPD patients.

Discussion

Pulmonary rehabilitation is a multidisciplinary program meant to improve physical, psychological and social performances in patients with chronic respiratory diseases including COPD(15,16).

Respiratory muscle training is a valuable method which provides additional benefits to PR. It may improve both muscle strength and endurance with clinical benefits in COPD patients who remain symptomatic, despite optimal therapy(14-16). The goal of RMT is the improvement of the respiratory muscle function, hypoxia, hypoventilation and dyspnea alleviation(16,17).

There are two types of exercises: **IMT (Inspiratory Muscle Training)** and **EMT (Expiratory Muscle Training).** Depending on the type of exercise, training may be on force (consisting of series of repeated breaths for increased resistance) or endurance (forced ventilation held for several minutes)(14).

Generally, inspiratory muscle training is used in patients with dyspnea as the predominant symptom and the expiratory muscles training in patients with productive cough.

Before starting the RMT, respiratory muscle strength will be assessed for each patient by measuring the maximal inspiratory/expiratory mouth pressure (PI_{max}/PE_{max}). The general recommendations are to perform inspiratory muscle training when the MIP value is below 60 cm H_20.

RMT uses different respiratory devices based on respiration against an incremental resistance ("incentive spirometer", "threshold inspiratory muscle trainer", "flutter valve")(17-19).

For the IMT, the patient will inspire through a device against a load equivalent to 30-60% of their maximal sustainable inspiratory pressure (the initial PI_{max})(17-19). The exercises will be performed 15-30 minutes/day, at home or in the rehabilitation centers, continued by rising gradually the resistance with 5% per week upon the patient's breathing effort tolerance. These maneuvers should be performed initially under the supervision of a healthcare provider.

The "incentive spirometer" is a device which contains some balls that rise upwards depending on the strength of the respiratory flow (Figure 1). During this type of training, the patient has to generate a target inspiratory-expirator flow which propels rise several balls at the top of the device. As the respiratory capacity improves, the balls rise up higher. The advantage is that the device provides an encouraging visual feedback for the patient. It is successfully used also in the perioperative period of the thoracic surgery.

Figure 1. *Incentive spirometer device*

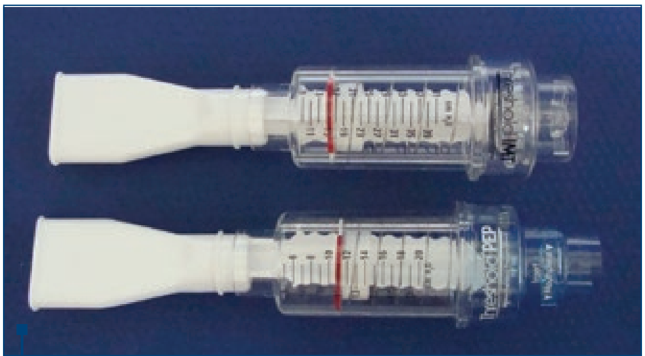

Figure 2. *Threshold device: PEP (Positive Expiratory Pressure) and IMT (Inspiratory Muscle Training)*

The "threshold inspiratory device", or "targeted inspiratory resistive trainers", provides adjustable inspiratory pressure for a targeted intensity of the airflow. This device incorporates a one-way valve that provides a graduate resistance (cm H_20) to inspiratory flow(14,17). The pressure is adjusted by rotating the distal extremity. This device is very easy to use by the patient. Threshold IMT training is performed daily for 15-30 minutes, at an intensity of 30-60 of PI_{max}. There is also a threshold device for the expiratory muscle training (Figure 2).

Isocapnic hyperventilation is a method of endurance training consisting in sustained forced ventilation for several minutes through a dispositive as POWERbreathe (Figure 3)(14). The advantage of this device is that it also has an electronic interface that can be connected to the computer to track the progress of the patient easier.

RMT will be performed regularly, about 30 minutes/day (divided in two training sessions or several sessions of 3-5 minutes with a 1-2 minute rest period between sessions). The intensity and frequency of the exercise will depend on patient tolerance and respiratory impairment. The workout must be supervised by a physiotherapist and the exercise program will be individualized to each patient. The respira-

Figure 3. *POWERbreathe device*

tory muscle exercise can be performed alone or added to a general physical training[14].

RMT will be continued by self-management indefinitely to maintain the training benefits[17, 20].

After sustained RMT, the external intercostal muscles of patients with COPD have the capacity to express structural remodeling. Both the proportion of type I fibers and the size of type II fibers increase after training. These structural adaptations could partly explain the functional improvements (increase in muscle strength and endurance) observed in long-term trained muscles in COPD patients[19].

The clinical benefits of RMT are: improvement of respiratory muscle function, relieving of dyspnea, increasing of effort capacity. There is also evidence that RMT improves the health-related quality of life in COPD patients[21,24-26]

The technique for breathing called "pursed lip breathing" controls the shortness of breath and the pace of breathing, making each breath more effective. The increase in expiratory pressure in this technique may reduce hyperinflation by avoiding partial collapse towards the end expiratory bronchioles. In this way it keeps the airways open longer, diminishes the work of breathing and dyspnea and improves oxygenation[15,22].

Other valuable breathing retraining technique is the "diaphragmatic breathing" or "abdominal breathing". The technique stimulates the abdominal muscles contraction during exhalation, ameliorates the coordination between thoracic and abdominal movements, and increases the tidal volume[15,22]. It also helps training the coordination between the rib cage and the accessory muscles[23].

The studies on respiratory muscle training had a duration ranging from 6-8 weeks to one year, and used RMT alone or combined with general physical training, with positive results in terms of dyspnea, PI_{max}, exercise tolerance and quality of life[24-26] .

Conclusions

Pulmonary rehabilitation is a multidisciplinary program meant to improve physical, psychological and social performances in COPD patients. Respiratory Muscle Training is a specific method which provides significant benefits inside PR programs. It may improve both muscle strength and endurance. RMT will start in special rehabilitation centers upon recommended protocols under supervision and then it will be continued for long-term at home. Several studies showed that RMT decreases dyspnea, enhances the effort capacity (according to the 6-minute walk test) and improves the quality of life in COPD patients. ■

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