

20. Chronic obstructive pulmonary disease (COPD)

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Summary

Reduced physical performance capacity is common in people with chronic obstructive pulmonary disease. Destruction of the small airways and alveoli, inflammation of the bronchi and deterioration of skeletal muscle strength contribute to the reduced performance capacity. Exercise training improves physical capacity and reduces dyspnoea (shortness of breath). Everyone should be recommended to engage in 30 minutes of physical activity in daily life, 5–7 days per week. Participation in exercise training should also be encouraged. The training should comprise aerobic exercise (fitness training), dynamic strength training and flexibility training (see table below). Suitable activities include cycling, walking, and fitness training on land or in the water. No training should occur at saturation levels (oxygen saturation) below 88–90 per cent.

Type of training	Intensity	Frequency (times/week)	Duration
Aerobic fitness training	Low intensity: 55–70% of max HR* 40–60% of VO ₂ max**	2–5	≥ 30 min.
	High intensity: > 70% of max HR > 60% of VO ₂ max 60–80% W max***	2–3	≥ 30 min.
Dynamic strength training Leg, hip, core and shoulder muscles	70% of 1 RM****	2	8–12 reps, 2–3 sets

* Max HR = Maximal Heart Rate.

** VO₂ max = Maximal Oxygen Uptake.

*** W max = Maximal workload.

**** RM = Repetition Maximum. 1 RM corresponds to the maximum weight that can be lifted through the entire exercise movement one time.

Definition

Chronic obstructive pulmonary disease (COPD) is defined as follows: “Chronic obstructive pulmonary disease (COPD) is a preventable and treatable disease with some significant extrapulmonary effects that may contribute to the severity in individual patients. Its pulmonary component is characterised by airflow limitation that is not fully reversible. The airflow limitation is usually progressive and associated with an abnormal inflammatory response of the lung to noxious particles or gases” (1).

Cause and risk factors

COPD is primarily caused by smoking (80–95%), but the disease can also occur in non-smokers. Increasing age, heredity, low socioeconomic group, occupational exposure to industrial pollutants and urban environments increase the risk of developing the disease (2). Despite the fact that the risk of developing COPD is not influenced by gender, we know that the effect of smoking is larger for women. People born with a deficiency of the enzyme alpha1-trypsin can develop COPD, above all if they smoke. When it comes to smoking, there is a clear dose-response relation, that is, the more years of smoking the greater the risk of developing COPD (2).

Prevalence/Incidence

COPD is a public health disease that occurs mostly in older persons. In the Nordic countries, 4–6 per cent of the adult population have COPD (2). The prevalence among 45-year-old smokers is 5 per cent, and rises thereafter to 25% for 60-year-old smokers, and 50% of smokers who are 75 years old (2). Approximately 50 per cent have mild COPD, just over a third moderate COPD, and the remainder severe COPD. Mortality has increased during the 1990s and 2000s. According to the cause of death registry, in 2003, 2558 people with COPD died in Sweden. Mortality is related to the severity of the disease.

Pathophysiology

COPD is a disease characterised by airflow limitation, which is only reversible in certain cases. The disease is progressive and characterised by an inflammatory process in the airways and lung tissue. Consequently, there is a loss of elastic recoil and increased airway resistance, which limits both inhalation and exhalation capacity. At a later stage of the disease, a thickening of the vessel walls occurs, which has a negative effect on the gas exchange, and can lead to both hypoxia (low oxygen levels) and hypercapnia (high carbon dioxide levels). In severe cases, elevated blood pressure in the pulmonary circulation can develop, i.e., pulmonary hypertension. This affects the right side of the heart with right-sided heart failure, cor pulmonale, which in turn can lead to the development of oedema in the body. Dynamic hyperinflation can also occur, where an increased amount of air remains in the lungs (3). The dynamic hyperinflation results in a deterioration of the

length-tension relationship of the diaphragm muscle, which leads to increased respiratory effort.

COPD is not only a lung disease but also a systemic disease, that is, other organs and systems in the body are also affected (4). People with COPD often have reduced cardiovascular capacity, impaired peripheral skeletal muscle strength, hormonal changes (reduced levels of anabolic steroids), systemic inflammation, and an increased energy expenditure at rest. This limits their ability to be physically active (5, 6). The peripheral skeletal muscle shows both structural and biochemical changes: decreased number of type I fibres (oxidative) and high number of type II fibres (glycolytic), decreased muscle mass, decreased capillary density, and reduced number of aerobic enzymes (7).

Symptoms and diagnosis

The diagnosis is made on the basis of symptoms such as chronic cough, coughed up mucous, dyspnoea, increased respiratory work, increased production of secretions, hyper-reactivity, and a long history of smoking and symptom development. The diagnosis is confirmed with a lung function test, where FEV% is less than 0.70. FEV% is the ratio of FEV₁ (forced expiratory volume in one second) to (F)VC (FVC = forced vital capacity and VC = vital capacity, where the highest value of FVC and VC is used) ($FEV\% = FEV_1 / (F)VC$). Establishing a COPD diagnosis requires also a reversibility test, that is, a spirometric examination after inhalation of beta2 agonists. COPD is classified into four stages based on the FEV₁ value. People with an FEV% less than 0.70 and FEV₁ equal to or greater than 80 per cent of expected value have pre-clinical COPD, an FEV₁ between 50–79 per cent – mild COPD, an FEV₁ between 30–49 per cent – moderate COPD, and an FEV₁ under 30 per cent of expected value – severe COPD (1).

Prognosis

People with reduced lung function ($FEV_1 < 50\%$ of expected value) have a higher mortality (8). If they also present with pulmonary hypertension, the prognosis is even worse (9). People with hypoxia (reduced oxygen level in the blood) and hypercapnia (elevated level of carbon dioxide in the blood) also have poorer survival, as do those with impaired nutritional status and functional status (e.g., shorter walking distance) (10, 11). Middle-aged people with moderate or severe disease who quit smoking live an average of seven years longer than those who continue to smoke.

Treatment principles

Quitting smoking is the most effective treatment and results in reduced mortality as well as reduced symptoms (cough and production of secretions). Rehabilitation that includes exercise training, education, a review of diet, etc., is important and improves physical capacity, quality of life and dyspnoea (12). The pharmacological treatment includes bronchodilators like tiotropium, ipratropium and beta2 agonists. Inhaled steroids are recommended for

people with an FEV₁ lower than 50 per cent of expected value (13). Continuous oxygen treatment for people with respiratory failure is necessary and increases longevity (14). People with COPD should also be vaccinated against influenza and pneumococci prophylactically.

Effects of physical activity

Exercise training and physical activity have been shown to have positive effects both physiologically and psychologically. In addition to improvement in physical capacity after a period of training, patients with COPD who have taken part in training are less afraid of exerting themselves and become more physically active in their daily lives (15, 16). The quality of life (disease control and dyspnoea) improves, the sense of well-being increases (17), and morbidity decreases (18). On the other hand, no training study has shown a change in lung function (16).

Effects of aerobic fitness training

Oxygen uptake capacity (VO₂ max), which is reduced in people with COPD, increases significantly after a period of training (19, 20). Endurance capacity also increases significantly (21). Minute ventilation (VE), heart rate, dyspnoea, blood lactate levels and hyperinflation are decreased for the same exercise (19, 20, 22, 23). The oxidative enzymes (24) and oxygen extraction (25) of skeletal muscle are improved as a result of a period of training. The maximal workload increases 13–24 per cent, while endurance capacity increases by an average of 87 per cent, that is, the greatest effect is achieved in endurance capacity (26).

Effects of strength training

Resistance training for the legs improves muscle strength and muscle endurance (27, 28). Aerobic capacity can also improve (29, 30).

Effects of aerobic training combined with strength training

A combination of strength training and aerobic training improves both muscle strength and aerobic capacity (31, 32).

Long-term effects

Studies that looked at long-term effects of exercise training have shown that training must be kept up, even if at a somewhat lower level, in order to maintain the positive effects achieved (16).

Indications

All people with COPD who have a lower quality of life and/or lower physical capacity should be offered rehabilitation that includes exercise training (1). The training can occur when the patients are in a stable phase of the disease, but also in close connection to a period of exacerbation (33). Everyone with COPD can take part in exercise training, regardless of age and severity of the disease.

Prescription

The physical performance capacity of people with COPD is reduced and engaging in some form of exercise training is of great value, both physically and psychologically to everyone. All exercise training should be balanced, that is, include aerobic training (fitness training), strength training (endurance strength) and flexibility training (see Table 1) (34). The training should start with a warm-up component and end with cool-down and stretching.

To begin with, the training should occur under controlled forms and under the direction of a physiotherapist. In connection with training, it is important to measure oxygen saturation. Saturation should not fall below 88–90 per cent. If the saturation decreases, in the first place the workload (intensity) and/or the duration of the training should be reduced. Pursed-lip breathing can be used during training to maintain the saturation at an acceptable level, that is, ≥ 90 per cent. For hypoxemic people and people who desaturate during training ($\text{SaO}_2 < 88\%$), oxygen supplementation should be given during training (14). It has also been shown that normoxemic people with COPD can exercise at a higher intensity and thereby see more improvement if they receive supplemental oxygen during training (21). However, patients who require supplemental oxygen during training should strive to train without oxygen supplementation so that, if possible, they can move to training outside medical care. People with a low body mass index ($\text{BMI} < 22$) should be recommended to take nutritional supplements to help increase peripheral muscle strength and aerobic capacity. Pre-medicating with bronchodilators can be recommended for patients who usually have the assistance of these medications.

Patients with mild and severe COPD can perform aerobic exercise at a high intensity (22, 35). For untrained individuals, however, it can be good to begin at a low intensity. Patients with severely limited ventilation can be recommended to begin with strength training or only flexibility training.

Table 1. Description of different types of training.

Type of training	Intensity	Frequency (times/week)	Duration
Aerobic fitness training	Low intensity: 55–70% of max HR* 40–60% of VO ₂ max**	2–5	≥ 30 min.
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Aerobic training can be carried out at low intensity or high intensity and either as continuous or interval training. The effects of the two types of training are equivalent (36). All activities involving large muscle groups, and thereby loading the oxygen-transporting organs, are beneficial. Suitable activities include cycling, walking, and fitness training on land or in the water (26). For interval training, 2–3 minutes of high intensity training should be alternated with 1–2-minute intervals of low intensity training or active rest. The training should continue for at least 8–10 weeks (26). The greatest effect of training (measured as oxygen uptake) is achieved through high intensity training (22, 37).

Strength training should include endurance strength training and above all target the muscles used for movement (38). Training for core and shoulder muscles should also be included. Each exercise should be performed 8–12 times in 2–3 repetitions at an intensity of 70 per cent of 1 RM (RM = repetition maximum, 1 RM corresponds to the maximum weight that can be lifted through the entire exercise movement one time) (26). To begin with, however, it is completely sufficient to perform only one set. A rest period of 1–3 minutes should be added between sets. The training should continue for at least 8–10 weeks. For low intensity training (40–50% of 1 RM), the training can occur daily; for higher intensity (70–80% of 1 RM), however, training should occur 2 times per week (37, 39, 40).

Flexibility training should cover mobility exercises for the neck, shoulders, thorax, thigh and calf muscles, and be included in every training session.

Functional mechanisms

In aerobic training, there is an increase in the skeletal muscle of the enzymes that stimulate oxidative metabolism and oxygen extraction improves (7). The number of mitochondria increases and blood lactate levels fall for the same degree of workload, that is, oxygen can be metabolised better and the aerobic capacity therefore improves (20). Minute ventilation decreases and oxygen uptake capacity (VO_2) increases (19, 20, 22). In strength training, the cross-section surface area of type I and type IIa fibres increases. Quality of life and symptoms improve through exercise training. This is probably an effect of both a physical and psychological nature.

Functional tests

A functional test should always be conducted before physical training begins, in part to facilitate planning of an appropriate training programme, and in part to facilitate evaluation of the training. All testing should include measurement of saturation.

Cycle test and treadmill test

Standardised maximal or submaximal tests are carried out to investigate the patient's tolerance and limitations with respect to physical exertion. Heart rate, ECG, blood pressure, oxygen saturation, shortness of breath, exertion and chest pain should be recorded both during and for a short time after the test. Note: If heart disease is suspected, an ECG and blood pressure should be measured up to 5 minutes after the loading stops.

Walking test

Standardised walking tests are often used in clinical contexts to assess physical capacity in relation to activities of daily life. The Incremental Shuttle Walking Test (ISWT) (41) is a maximal test in which walking speed is increased every minute. The Endurance Shuttle Walking Test (ESWT) (42) is an endurance test that uses the same speed throughout the test. In both of these tests, the patient walks round two cones placed 9 metres apart. In a 6- or 12-minute walk test, the patient is encouraged to walk as far as possible in 6 or 12 minutes, respectively, on a measured stretch of hallway (43, 44). In all of the walking tests, the walking distance, heart rate, oxygen saturation, and perceived exertion and shortness of breath are measured on the Borg scale (45).

Muscle function

Both dynamic muscle strength and endurance can be measured with isokinetic devices. Dynamic muscle strength can in addition be measured by repetition maximum (RM). A suitable way to measure dynamic endurance strength is to have the person perform

a maximum number of repetitions at a given load. After a period of training, the test is repeated with the same load. An increase in the number of repetitions is an indication of an increase in muscle endurance.

Perception of quality of life and symptoms

General health-related quality of life can be measured with the Short-Form Health Survey (SF-36) (46), while disease-specific quality of life is often measured with the Chronic Respiratory Questionnaire (CRQ) or St. George's Respiratory Questionnaire (48). The severity of symptoms can be measured with a visual analogue scale (VAS) or the Borg scale.

Risks

No serious events need occur if the patient has undergone a functional test with ECG recording before commencing training, so that the physical limitations the patient demonstrates are known to the person in charge of or instructing the training. No strenuous training should occur if the disease is deteriorating. Many patients with COPD also have decreased cardiac function and high blood pressure. Blood pressure should therefore be monitored during the training.

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