Commentary

Impaired function of upper limb muscles in patients with chronic obstructive pulmonary disease

Chronic obstructive pulmonary disease (COPD) is an incurable disease that is one of the most frequent causes of mortality in the world. In 1990, it has been the sixth leading cause of death worldwide but is projected to rank three by 2020. Data from prevalence surveys estimate that 15-25 per cent of adults at the age of 40 yr or above may have COPD according to their airflow limitation¹.

COPD is usually associated with a number of secondary impairments such as cardiac, metabolic, peripheral muscle and psychosocial dysfunction. Hence, COPD patients often suffer from considerable comorbidities which substantially accelerate deterioration of the patient's condition. A major problem among these secondary impairments is skeletal muscle dysfunction, which is typically characterized by reduced muscle strength and endurance. Several factors contribute to this condition:

Inactivity and deconditioning: Hypoventilationinduced hypoxia and hypercapnia cause dyspnoea and thereby reduce the patients' exercise tolerance. Exercise intolerance is the most frequent complaint of COPD patients². Patients keep down their muscular activity in order to reduce dyspnoea. As a consequence, muscular deconditioning further decreases exercise capacity and may substantially compromise the patients' daily life.

Impaired metabolic situation: In chronic pulmonary disease, impaired pulmonary gas exchange causes hypoxaemia and hypercapnia. Consequently, the oxygen supply to the muscles is reduced. The metabolic situation may be further compromised by fatigue of the respiratory muscles due to the increased work load of respiratory muscles including auxiliary respiratory musculature. In addition, cardiovascular dysfunction such as right ventricular overload (cor pulmonale) and disturbances in microcirculation may aggravate tissue hypoxia and hypercapnia. As an adaptive response, muscle metabolism changes in favour to anaerobic metabolism and to increased lactic acid production. The altered muscle energy metabolism in COPD patients leads to premature muscle acidosis and consequently, to increased muscle fatigability and reduced exercise capacity³.

Structural alterations of skeletal muscle: Chronic ventilatory disease is often accompanied by weight loss and peripheral muscle atrophy. This occurs in about 40-50 per cent of COPD patients but probably, this percentage is even underestimated⁴. It is characterized by enhanced protein degradation and associated with a change in fiber type composition². One of the most typical abnormalities in COPD patients is a shift from fiber type I into type II. A meta-analysis of muscle fiber data showed that the type II-to-type I proportion was positively associated with the reduction in forced expiratory volume in one second (FEV₁) and FEV₁/ forced vital capacity (FVC)⁵. Muscle wasting and a reduced proportion of slow fibers result in muscle weakness and premature muscle fatigue.

Inflammation and oxidative stress: Systemic inflammation may also impair muscle perfusion and metabolism. COPD patients present higher plasma levels of proinflammatory cytokines which are even more increased by exercise⁶. Moreover, inflammation has been shown to trigger oxidative stress, which was associated with reduced skeletal muscle endurance⁷.

It should be remarked that breathing can affect peripheral muscle function via neural interactions originating from afferent and central respiratory activity. These influences can be demonstrated also in healthy subjects under normal conditions, but these are enhanced in resistive loaded breathing or with increased respiratory drive - situations which are similar to that of COPD patients. Resistive loading of inspiration and expiration reduced voluntary submaximal contraction force of upper and lower limb muscles in a differential way⁸ while maximal contraction force was only reduced in leg but not in arm muscles⁹.

However, muscle weakness and increased fatigability are not the only limitations of skeletal muscle function. Neural interactions between respiratory and non-respiratory motor processes modify the temporal course of motor actions. Precision movements are particularly sensitive to these influences. Accuracy of finger movements has been found to vary in a respiratory phase-dependent manner. In turn, the movements exerted a modulating effect on the respiratory rhythm¹⁰. These effects were greater under hypercapnic conditions¹¹ indicating that neural interactions between breathing and other motor activities may be more important when ventilation is compromised.

Muscle dysfunction mostly concerns lower limb muscles of COPD patients. It has been considered to be one of the most important exercise-limiting factors³. Reduced muscle strength and endurance due to inflammation, oxidative stress, decreased proportion of oxidative fibers and altered energy expenditure have predominantly been observed in leg muscles^{3,5,7}. Several studies show that oxidative capacity and muscle performance are better preserved in the upper than in the lower limb^{12,13}. Only a few authors showed reduced strength and endurance of upper limb muscles in COPD patients^{14,15}.

In this issue, Shah and co-workers¹⁶ clearly demonstrated that strength and endurance of upper limb muscles were significantly reduced in COPD patients compared with age- and gender-matched healthy subjects. The authors investigated maximum voluntary handgrip strength and handgrip endurance at 1/3rd of individual maximum handgrip strength. Their results showed that endurance was more affected than strength both in male and female patients. In addition, they found a positive correlation between handgrip muscle strength and both FVC and FEV₁. The authors rightly emphasize the significance of upper limb muscle strength for routine day-to-day activities. Moreover, upper limb muscles, especially muscles of hand and fingers, often have to perform precision movements with low demands on muscle strength and endurance, which play an essential role in daily life. Therefore, early detection and treatment of impaired function of upper limb muscles have particular importance with respect to the patients' health-related quality of life.

Skeletal muscle dysfunction can impair the situation of patients with chronic lung diseases in several ways. Firstly, increased energy expenditure, earlier onset of fatigue and increased lactic acid production worsen the metabolic situation of the tissues resulting in aggravated hypoxaemia and lactic acidosis. These additional respiratory drives further increase respiratory work load and promote respiratory muscle fatigue. Secondly, dysfunction of peripheral muscles considerably contributes to exercise intolerance, which amplifies the patients' inactivity and may result in isolation and depression. Moreover, it upholds a vicious cycle that more and more deteriorates the disease. Finally, reduced muscular performance is not only due to muscle weakness and increased fatigability but also to affection of fine motor skills by neural influences from central respiratory activity. This aspect has particular importance for many everyday activities and concerns muscle function of the upper limb much more than that of the lower limb. Impaired function of arm and hand muscles substantially contributes to a progressive inability of the patients to manage their daily life.

Even though COPD is still an incurable disease, there are many therapeutic ways to improve the patients' condition. Improving skeletal muscle function is an essential column in the treatment of COPD patients². Pulmonary rehabilitation includes exercise training programmes aiming to increase exercise capacity. Exercise training counteracts muscle wasting, improves the patients' metabolic situation and reduces dyspnoea. Most exercise programmes have focused on training of leg muscles¹⁷. However, as muscular dysfunction also concerns upper limb muscles, these muscles should be included in training programmes. Besides strength and endurance, fine motor skills might also be considered in rehabilitation programmes in order not only to improve the patients' disease status but to bring benefit for their general situation of everyday life.

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