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Expert Column

Exercise For Restrictive Pulmonary Diseases

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Chronic respiratory diseases (CRDs) are diseases of the airways and other structures of the lungs as defined by the World Health Organization (WHO). In addition to tobacco smoking as the commonest aetiology, other risk factors for CRDs include aerosol-based environmental origin irritants like air pollution, occupational chemicals and dust, and frequent childhood respiratory infections. CRDs can subsequently be grouped into 4 major categories (Prezant et al., 2008):

I. Upper respiratory tract disease: Chronic rhinosinusitis and reactive upper airways dysfunction syndrome
II. Lower respiratory tract diseases: Reactive lower airways dysfunction syndrome, irritant-induced asthma, and chronic obstructive airways diseases (COAD/COPD)
III. Parenchymal or interstitial lung diseases: Sarcoidosis, pulmonary fibrosis, and bronchiolitis obliterans
IV. Cancers of the lung and pleura

The commonly occurred interchangeably among all 4 are lower respiratory tract and parenchymal lung diseases, or better known as obstructive and restrictive lung disorders with regards to their pathogenesis nature despite their almost similarities in pathophysiology. Hence, diagnosing them requires a lung function test to differentiate one another. Obstructive lung disorders are mainly bronchial asthma (BA) and chronic obstructive pulmonary disease (COPD), which later can be subdivided into chronic bronchitis “Blue Bloaters” and emphysema “Pink Puffers”. Whereas, restrictive lung disorders are interstitial lung disease, pneumoconiosis and sarcoidosis. Lung cancer and tuberculosis can be considered as restrictive in nature albeit the mixed picture presentation in diagnostic laboratory findings.

Restrictive Lung Diseases

People with restrictive lung disease cannot fully fill their lungs with air. Their lungs are restricted from fully expanding. In contrast to obstructive lung disease which is characterized by swollen airway (thickening of the respiratory wall) leading to bronchoconstriction (narrowing of respiratory passage) with excessive production of mucus (stimulating chronic irritative bouts of coughing) due to ongoing prolonged inflammation process, restrictive lung disease is due to stiffening of chest wall tissue, weakened muscles or even damaged respiratory nerves resulting difficulty in fully expanding the lungs, thus more difficult to fill the lungs with enough air for respiration purpose as demanded by the body. In short, obstructive lung disease is a "clogged/narrowed" condition, whilst the restrictive type is a "tight/stiffened" condition. Here are the examples of this type of respiratory illness (Isa, 2020);

a) Interstitial lung disease: Idiopathic Lung Fibrosis (scarring of alveolar tissue).
b) Pneumoconiosis: Occupational dust; asbestos (Asbestosis) and silica (Silicosis).
c) Sarcoidosis: Autoimmune granulomas altering multiple organs' structure and function.
d) Obesity: Obesity Hypoventilation Syndrome
e) Scoliosis: Abnormal "S"-shaped curvature of spine, resulting depressed chest wall shape.
f) Neuromuscular diseases:
g) Childhood muscular dystrophy (Duchenne and Becker)
h) Adulthood progressive motor neurons breakdown (Amyotrophic Lateral Sclerosis/ALS)

Lung function tests like spirometry and peak flow meter are the ones able to diagnose a patient with the symptom of exertional shortness of breath to be whether obstructive or restrictive in nature. It is based on the parameters of Forced Vital Capacity/FVC (volume of air forcibly blown out after a full inspiration) and Forced Expiratory Volume/FEV1 (amount of air exhaled from the lungs in the first 1 second after full inspiration). A low FEV suggestive of obstructive lung disease, on the other hand, an addition of low FVC signifies restrictive lung disease.

Lung Cancer

Squamous Cell Carcinoma (SCC) is the commonest type of lung malignancy, however, Adenocarcinoma is trending in recent years. SCC is associated with male and smoking prevalence, while Adenocarcinoma type is linked to female and non-smoking populations. It is postulated that this fact is due to secondary smoking (passive smoker) 'culture' existing at large within our very own society. All together, any types of cancer are almost always in a linear relationship with aging as evidenced through a Malaysian study (Liam et al., 2006) stating the age of peak incidence of lung cancer is 7th decade of life.

At clinical stages I and II, patients are able to undergo curative surgical resection of the tumor site of the lungs. Inductive therapy, in the form of chemotherapy or in combination with radiotherapy, is applied to stages III and IV patients in order to downstage the lung malignancy prior to curative surgical resection if feasible based on the treating pulmonologist's (respiratory physician) judgment in agreement with cardiothoracic surgeon's further evaluation.

Tuberculosis

Tuberculosis is a chronic lung infection caused by *Mycobacterium tuberculosis*. The mode of spread among humans is via aerosol droplet transmission hence the lungs are often the focus of tuberculous disease although TB may present with the disease in any organ system (Chakrabarti et al., 2007). In Malaysia, it is more prevalent among the foreign labor workers and in deeply rural regions due to incomplete as well as inaccessibility to BCG (Bacillus Calmette–Guérin) vaccination program. Recent years of vaccine hesitancy movements worldwide might just hamper the efforts done to eradicate this once contagiously fatal illness. A cross-sectional study by Amaral et al. (2015) using data collected from across the globe, concluded that tuberculosis is associated with a mixed presentation of airflow obstruction and restrictive patterns on spirometry assessment.

Exercise Testing for Pulmonary Disease

Submaximal graded exercise test (GXT) is used to assess cardiopulmonary function and fitness by providing an objective measure of exercise capacity, mechanisms of exercise intolerance, prognosis, and disease progression and treatment response. Modifications of traditional protocols depend on functional limitations and the onset of dyspnea. Test duration of 8–12 min is optimal for those with mild-to-moderate illness (Buchfuhrer et al., 1983), whereas a test duration of 5–9 min is recommended for patients with severe and very severe disease (Benzo et al., 2007). SpO_2 monitoring must be done for these patients as they may exhibit oxyhemoglobin desaturation with exercise, with the maintenance of SpO_2 > 90% is recommended.

However, individuals with pulmonary disease may have ventilatory limitations to exercise. Thus, prediction of VO_2peak based on age-predicted HRmax may not be appropriate as criteria for terminating the submaximal GXT. The 6-minute walking test (6MWT) and shuttle walking test can assess functional exercise capacity in individuals with more severe pulmonary disease and in settings that lack exercise testing equipment. The use of bronchodilator therapy as a standby emergency medication is beneficial for such individuals. Exertional dyspnea is a common symptom in people with any pulmonary disease. The modified Borg Category-Ratio 0–10 (CR10) Scale (Figure 1) has been used extensively to measure dyspnea before, during, and after exercise (Ries, 2006). Patients should be given specific, standardized instructions on how to relate the wording on the scale to their level of breathlessness. In addition to standard termination criteria, exercise testing may be terminated because of severe arterial oxyhemoglobin desaturation. The exercise testing mode is walking or stationary cycling. Walking protocols may be more suitable for individuals with severe diseases who lack the muscle strength to overcome the increasing resistance of cycle leg ergometers. Arm ergometry may result in increased dyspnea that may limit the intensity and duration of the activity.

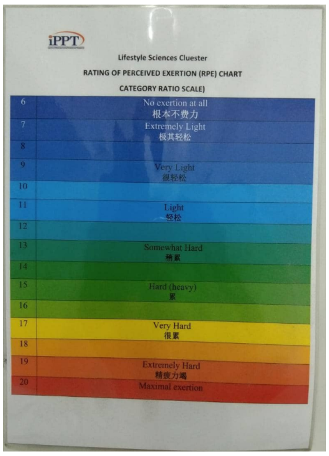

Figure 1: Modified Borg CR10 Scale for Dyspnea
Photo by IPPT

Exercise Prescription

Despite substantially less investigation into the benefits of exercise training in non-obstructive chronic lung diseases, strong scientific evidence supports the inclusion of exercise training for many lung diseases other than Bronchial Asthma and COPD with demonstrated clinical and physiologic benefits (Rochester et al., 2014). However, the exercise programs should be modified to include disease-specific strategies. Methods for adapting exercise training in patients with restrictive chronic lung disease have been published (Holland et al., 2013). Exercise training recommendations have been specifically presented for patients with stable interstitial lung disease who are receiving optimal medical management. For these patients, the FITT guidelines as below:

F: 3-5 day/week

I: Moderate intensity. Intensities should be below those that would provoke severe dyspnea, oxygen desaturation, or in some cases, hypertensive episode due to chronic illness.
T: Morning
T: Aerobic exercise should comprise the core component of the exercise program. Resistance exercise training may be added after the aerobic training is established and well tolerated.

Precautions:
Arm ergometry, heavy resistance training, and pelvic floor exercise should be avoided to reduce the risk of a Valsalva maneuver.

Apart from the standard ACSM guideline meant for COPD, according to a local guideline by National Cancer Society Malaysia (NCSM) issued in 2019; seated exercises are the best form of training for lung cancer patient to build strength and endurance, eliminating the risk of difficulty in breathing; with inhalation during motion and exhalation when completing. This simple exercise steps can be used for other restrictive lung diseases and tuberculosis patients as well, due to its efficacy and safety with minimal effort without much exertion. The seated exercise consists of:

1. Leg lift (alternating lift legs up to shoulders while sitting on a chair for 10 times)

Figure 2: Leg Lifts
Photo by Dr. Azizi

2. Seated kicks (kick foot off floor while sitting on a chair for 10 times)

Figure 3: Seated Kicks

Photo by Dr. Azizi

3. Overhead arm lifts (lift arms towards ceiling while sitting on a chair for 10 times)

Figure 4: Overhead Arm Lifts

Photo by Dr. Azizi

4. Windmills (circling arms while sitting on a chair for 10 times)

Figure 5: Windmills

Photo by Dr. Azizi

5. Pursed lip breathing is a good method to 'retrain' breathing regulation for lung cancer patients, simply by breath in through nostrils and slowly breath out through mouth by pursing the lips (like "blowing the candle" or "pulling out a thread from mouth").

6. Buteyko breathing technique; a nasal breathing (inhaling and exhaling via the nostrils) method; can be applied as the exercise progresses, to control and prevent hyperventilation episodes caused by the pulmonary diseases.

Special Considerations

Peripheral muscle dysfunction in the case of neuromuscular diseases (eg., Duchenne/Becker and ALS) contributes to exercise intolerance and is significantly and independently related to increased use of health care resources, poorer prognosis, and mortality. Maximizing pulmonary function using bronchodilators before exercise training in those with airflow limitation can reduce dyspnea and improve exercise tolerance (Spruit et al., 2013). Inspiratory muscle weakness is a contributor to exercise intolerance and dyspnea in those with chronic lung disease. In patients receiving optimal medical therapy who still present with inspiratory muscle weakness and breathlessness, Inspiratory muscle training (IMT) , despite no clear guidelines for it, may prove useful in those unable to participate in exercise training with an intensity of the training load of at least 30% of maximal inspiratory pressure has been recommended (Langer et al., 2009). IMT improves inspiratory muscle strength and endurance, functional capacity, dyspnea, and quality of life which may lead to improvements in exercise tolerance (Gosselink et al., 2011). Supplemental oxygen is indicated for patients with $SpO_2 < 88\%$ while breathing room air (Qaseem et al., 2011). This recommendation applies when considering supplemental oxygen during exercise. In patients using ambulatory supplemental oxygen, flow rates will likely need to be increased during exercise to maintain $SpO_2 > 88\%$. Although inconclusive, there is evidence to suggest the administration of supplemental oxygen to those who do not experience exercise-induced hypoxemia may lead to greater gains in exercise endurance particularly during high intensity exercise (Nonoyama et al., 2007). Individuals suffering from acute exacerbations of their pulmonary disease should limit exercise until symptoms have subsided.

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