J Bras Pneumol. 2019;45(6):e20190351
http://dx.doi.org/10.1590/1806-3713/e20190351

Pulmonary rehabilitation: various diseases, many approaches, and multiple questions

Paulo José Zimermann Teixeira[1,2,3,a], Simone Bernardes[2,b], Marcelo Nogueira[2,3,c]

In 1605, Sir Francis Bacon said, "if a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties". Pulmonary rehabilitation has been recognized to improve dyspnea and quality of life since the 1960s; however, despite being such a well-established form of treatment, pulmonary rehabilitation still raises many questions.[1] Although pulmonary rehabilitation has become a well-established treatment for COPD, new evidence suggests that it can be used in other situations,[2] pulmonary rehabilitation having been reported to reduce mortality among pulmonary fibrosis patients undergoing single lung transplantation.[3]

In the current issue of the JBP, three articles demonstrate that pulmonary rehabilitation plays an important role in the treatment of chronic lung diseases, particularly COPD. In addition, the authors of the studies discuss the central role that physical exercise plays in the treatment of chronic lung diseases, as well as discussing how to implement exercise interventions and evaluate their outcomes. Although there is a body of evidence that pulmonary rehabilitation reduces dyspnea and exacerbations, as well as improving quality of life and exercise performance,[4] there is still controversy regarding the best model for exercise training. Although the six-minute walk test is the most widely used exercise test, it is a submaximal test that provides less detailed information than does ergospirometry. In the current issue of the JBP, Adolfo et al.[5] published a systematic review and meta-analysis of randomized studies, the objective of which was to compare high-intensity interval training and continuous training in terms of their effects on functional capacity and cardiovascular variables in patients with COPD. Of the 78 articles that were initially retrieved, only 6 were included in the meta-analysis, and all 6 were found to have a high risk of methodological bias. Although the authors found no difference between high-intensity interval training and continuous training or other interventions in terms of their effects on relative maximal oxygen consumption (VO_2), absolute maximal VO_2, and cardiovascular variables in COPD patients, the findings should be interpreted with caution because of their heterogeneity. Meta-analyses including methodologically flawed clinical studies can describe the current state of knowledge but cannot provide evidence upon which a given intervention can be based. Therefore, the question remains unanswered. Perrota et al.[6] evaluated the effects of a high-intensity rehabilitation program on ventilatory efficiency, i.e., the ratio of minute ventilation to carbon dioxide production (V_E/VCO_2) in 25 patients with COPD and stage I-IIIa non-small cell lung cancer undergoing rehabilitation three weeks before lobectomy. All of the patients had a peak VO_2 of 10-20 mL/kg per min or an FEV_1 of < 50% of predicted. Peak VO_2 and V_E/VCO_2 were found to have improved significantly after the rehabilitation program, showing that rehabilitation can improve ventilatory efficiency, improve aerobic capacity, and reduce postoperative risk, even in patients with severely impaired lung function. In addition, pulmonary rehabilitation was found to reduce dynamic hyperinflation and respiratory rate during exercise.[6] Although peak VO_2 during cardiopulmonary exercise testing is the best independent predictor of complications following pulmonary resection in patients with lung disease, ventilatory efficiency (V_E/VCO_2) during cardiopulmonary exercise testing has been shown to be an independent predictor of complications and mortality (in patients with a $V_E/VCO_2 > 35$).[7,8] Neder et al.[9] addressed the importance of ventilatory efficiency in patients with COPD, even in those with preserved lung function; in many cases, ventilatory efficiency can explain the discrepancy between dyspnea and lung function (FEV_1) and predict postoperative morbidity and mortality. In addition, the authors reported that pulmonary hypertension and heart failure can lead to an increase in V_E/VCO_2. Therefore, the use of ergospirometry before and after pulmonary rehabilitation can provide a deeper understanding of the outcomes to be evaluated. In fact, as the number of approaches increases, so does the number of questions. Pulmonary rehabilitation is a multidisciplinary program that addresses several aspects of the disease and underscores the importance of reversing physical deconditioning and understanding skeletal muscle issues. Mansour et al.[10] sought to establish cutoff points for clinical and functional variables for sarcopenia and dynapenia in 20 COPD patients who had moderate to very severe disease and skeletal muscle dysfunction and who were referred for pulmonary rehabilitation. Sarcopenia was diagnosed on the basis of skeletal muscle mass index (kg/m^2), as assessed by bioelectrical impedance analysis, whereas dynapenia was diagnosed on the basis of handgrip strength, as assessed with a hydraulic dynamometer. The major findings of the study[10] were that sarcopenia and dynapenia can be predicted by pulmonary function test results, respiratory muscle strength, and physical performance on the incremental shuttle walk test. Despite advances in the understanding of skeletal muscle

1. Disciplina de Pneumologia, Departamento de Clínica Médica, Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre (RS) Brasil.
2. Programa de Pós-Graduação em Ciências da Saúde, Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre (RS) Brasil.
3. Pavilhão Pereira Filho, Santa Casa de Porto Alegre, Porto Alegre (RS) Brasil.
a. http://orcid.org/0000-0002-4906-6970; b. http://orcid.org/0000-0003-0498-5305; c. http://orcid.org/0000-0003-1765-3123

dysfunction, there are currently no clear criteria or tools to define sarcopenia and dynapenia. According to the revised European consensus statement on the definition and diagnosis of sarcopenia,[11] some cutoff points for the diagnosis of sarcopenia are arbitrary, and the development of validated cutoff points will depend on normative data and their predictive value for hard endpoints. In addition, for height-dependent measures of sarcopenia (gait speed and muscle strength), studies are needed in order to establish whether gender- and region-specific thresholds can improve outcome prediction. Manini and Clark,[12] proponents of the term dynapenia, recognize that there is a lack of data to define cutoff points for dynapenia.

Despite the fact that there is ample evidence supporting the use of pulmonary rehabilitation regardless of its level of complexity, pulmonary rehabilitation continues to be a health care challenge. Many questions remain, and many components require better defined protocols and clearer measures that are relevant and feasible. In the meantime, we must live with our uncertainties and question everything, as Sir Francis Bacon would.

REFERENCES

1. Hodgkin JE. Historical Perspective of Pulmonary Rehabilitation. In: Hodgkin JE, Celli BR, Connors GA. Pulmonary Rehabilitation: Guidelines to Success. 4th ed. Philadelphia: Mosby Elsevier; 2009, p. 1-7.
2. Dowman L, Hill CJ, Holland AE. Pulmonary rehabilitation for interstitial lung disease. Cochrane Database Syst Rev. 2014;(10):CD006322. https://doi.org/10.1002/14651858.CD006322.pub3
3. Florian J, Watte G, Teixeira PJZ, Altmayer S, Schio SM, Sanchez LB, et al. Pulmonary rehabilitation improves survival in patients with idiopathic pulmonary fibrosis undergoing lung transplantation. Sci Rep. 2019;9(1):9347. https://doi.org/10.1038/s41598-019-45828-2
4. Rodrigues FM, Loeckx M, Trossters T and Janssens W. The role of pulmonary rehabilitation in the prevention of exacerbations of chronic lung diseases. In: Burgel PR, Contoli M, López-Campos JL, editors. Acute Exacerbations of Pulmonary Diseases (ERS Monograph). Sheffield: European Respiratory Society; 2017. p. 224-246. https://doi.org/10.1183/2312508X.10016916
5. Adolfo JR, Dhein W, Sbruzzi G. Intensity of physical exercise and its effect on functional capacity in COPD: systematic review and meta-analysis. J Bras Pneumol. 2019;45(6):e20180011. https://doi.org/10.1590/1806-3713/e20180011
6. Perrotta F, Cennamo A, Cerqua FS, Stefanelli F, Bianco A, Musella S, et al. Effects of a high-intensity pulmonary rehabilitation program on the minute ventilation/carbon dioxide output slope during exercise in a cohort of patients with COPD undergoing lung resection for non-small cell lung cancer. J Bras Pneumol. 2019;45(6):e20180132. https://doi.org/10.1590/1806-3713/e20180132
7. Brunelli A. Ventilatory efficiency slope: an additional prognosticator after lung cancer surgery. Eur J Cardiothoracic Surg. 2016;50(4):780-781. https://doi.org/10.1093/ejcts/ezw127
8. Torchio R, Guglielmo M, Giardino R, Ardissone F, Ciacco C, Gulotta C, et al. Exercise ventilatory inefficiency and mortality in patients with chronic obstructive pulmonary disease undergoing surgery for non-small-cell lung cancer. Eur J Cardiothorac Surg. 2010;38(1):14-9. https://doi.org/10.1016/j.ejcts.2010.01.032
9. Neder JA, Berton DC, Arbex FF, Alencar MC, Rocha A, Sperandio PA, et al. Physiological and clinical relevance of exercise ventilatory efficiency in COPD. Eur Respir J. 2017;49(3). pii: 1602036. https://doi.org/10.1183/13993003.02036-2016
10. Mansour KMK, Goulart CL, Carvalho-Junior LCS, Trimer R, Borghi-Silva A, Silva ALG, et al. Pulmonary function and functional capacity cut-off point to establish sarcopenia and dynapenia in patients with COPD. J Bras Pneumol. 2019;45(6):e20180252.
11. Cruz-Jentoft AJ, Bahat G, Bauer J, Boirie Y, Bruyère O, Cederholm T, et al. Sarcopenia: revised European consensus on definition and diagnosis. Age Ageing. 2019;48(1):16-31. https://doi.org/10.1093/ageing/afy169
12. Manini TM, Clark BC. Dynapenia and aging: an update. J Gerontol A Biol Sci Med Sci. 2012; 67(1):28-40. https://doi.org/10.1093/gerona/glr010