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EDITORIAL

Current Status of Pulmonary Rehabilitation: Introductory Remarks on Pulmonary Rehabilitation, the Importance and the Practice

In 1994, the Pulmonary Education and Research Foundation released a VHS tape, a program for the health-care professional, entitled "Essentials of Pulmonary Rehabilitation—Taking Control of Life Again." In the introductory remarks to this video Dr. Thomas L. Petty says: "Pulmonary rehabilitation has come of age. In fact, a program of a pulmonary rehabilitation has become the standard of care for those patients, who want to do more than ordinary care in order to improve their quality of life and probably even their length of life. Pulmonary rehabilitation goes beyond ordinary care. It contains components of education, breathing training, oxygen in selected patients, and of course, pharmacologic agents. And, very importantly, patient support groups…" (1). We think, it is important to note also that Dr Petty wrote a detailed approach on pulmonary rehabilitation (PR) in 1980 (2). In this article, he essentially outlined everything what we now think is important in PR.

We started with the first paragraph of our introduction to a new series on PR because of two reasons: (1) Nearly 25 years ago Dr Petty said and showed every important aspect of PR that are currently detailed in clinical practice guidelines and statements of major pulmonary societies like the American Thoracic Society and the European Respiratory Society. Has anything changed since then? Have we reached the knowledge and, more importantly, the *practice* of PR the critical level that will change *the lives of those who need it most?* (2) In order to see where we are, we need to take a broad look at the current *state of art*. Therefore, we decided to launch a series of invited reviews from the experts and authorities of their respective fields.

On a personal level, at the time of the video production, Dr Porszasz took part of a study involving PR of some of the most debilitated patients and experienced the most dramatic life-saving effects of this highly effective, nonpharmacologic treatment option for patients with chronic pulmonary diseases. In this program, high-intensity exercise training yielded an average of 36% increase in peak work rate on the incremental test and a 77% increase in endurance on the constant work rate at an intensity of 80% of the prerehabilitation peak work rate (3). This work showed most of the physiologic effects of exercise training that is known today! These include effects on respiratory control: deeper and less frequent breathing pattern, resulting in lower minute ventilation, allowing the individual to exercise longer without reaching the level of shortness of breath that characteristically limits exercise tolerance of these patients. Later, in another rehabilitative training study, Emtner et al. showed a much more dramatic increase in exercise endurance approaching 300% improvement compared to pretraining endurance (4). In this study, many of our patients reached a predetermined target of 20 minutes and we stopped them from exercising more. In the same study, we showed—for the first time—that exercise training, possibly through the mechanism of slower and deeper breathing, contributes not only to less ventilatory demand, but this leads to less dynamic hyperinflation (5).

Indeed, the current clinical practice guidelines and society position statements emphasize that PR is a comprehensive intervention that includes exercise training, education, and behavior change. The program is designed to improve the physical and psychological condition of people with chronic respiratory disorders and to achieve a long-term adherence to health-enhancing behaviors (6–9). The effects of PR seem to be age independent (10), therefore all age groups are potentially equal targets.

On the contrary, that the widely accepted view is that PR is *standard of care*, the statistics from a survey involving 430 centers from 40 countries show that less than 0.05% of the eligible 64 million people took part in PR programs (11)! These data do not support that PR is standard of care in most countries, including those with the most developed health-care systems! On the patients side, cumulatively 60–80% of responders never heard of PR, have insufficient information, lack of knowledge or not sure if it will help; lack of available PR service in the area, or state that the available PR is not covered by the insurance (7). A recent study in the US showed that a lower than expected fraction of eligible patients took part in PR and those who took part in the program did not continue long enough to gain full benefits (12). A meta-analysis of PR programs across seven countries (US, UK, Canada, Ireland, Australia, New Zealand, and Sweden), on the contrary that they all have high-quality and high-access health care systems, the total number of the capacity of the PR programs available was $<1.2\%$ of the COPD population (ranged from a total of 1328 to 8927 programs in Sweden and Canada, respectively) (13). It seems, therefore, that although the science of rehabilitation is relatively well known, the delivery system is failing. Unlike any players of the pharmacologic treatment option, the PR is not valued by the medical community at large as therapeutic option, otherwise it would be recognized at its value.

In the last 10 years, the number of publications on the topic "pulmonary rehabilitation" was four times as much (close to 20,000) than all years before, combined. It is shocking that there are no studies showing that PR improves

mortality. In contrast, oxygen therapy is widely recognized as "standard of care" for those with hypoxemia simply because two landmark studies in the US (14) and in the UK (15) showed *survival benefit* on a mere 203 and 87 patients, respectively. Who would deny a therapy from patients that is shown to improve survival? A quarter of a century after Dr Petty said in his opening remarks in that video in 1994: "… who want … to improve their quality of life and probably even their length of life…"; still there are no data available to show that PR does in fact improves survival. It has been shown however that physically active population has a lower risk to death (16), giving a clue that if PR was to increase the activity level, it might bring about survival benefit. This has not been shown so far and it is generally accepted that higher fitness level has only a permissive effect; the participants do not necessarily adopt a more active lifestyle unless there is a behavioral intervention and the behavioral changes are permanently imprinted (17). Indeed, a poor physical activity after an acute exacerbation and a poor improvement in 6MWD (<30 m) after PR are the strongest predictors of mortality (18, 19).

The rehabilitative training directly affects the muscles participating in that specific movement or activity. There are specific changes in the muscles and the motor units that are related not only to aging, activity level, and training condition (20, 21), but the changes in COPD are different from those of normal aging (21) including fiber type composition, capillarization, and mitochondrial activity. Some of these changes seem to be reversible with physical training, signaling again the need to implement and emphasize the importance of physical activity in the PR programs. Unfortunately, 86% of PR participants are "inactive maintainers," meaning that in average they had ~3100 steps/day throughout a 9-month follow-up period after a PR. These data suggest that most patients do not respond well to activity interventions, which raises again the importance of behavioral component of PR (22). A physical activity-stratified analysis done on 8171 veterans in a follow-up study (8.7 ± 4.4 years), however, showed that being fit reduced the hazard ratio for all-cause mortality by half (hazard ratio: 0.52 and 0.51 in the inactive and active population, respectively) (23). This observation emphasizes the importance of cardiovascular fitness regardless of the habitual activity and calls for a greater importance of fitness than the activity itself in improving mortality.

Delivery of physical training raises a whole series of questions. Whether it should be dynamic/aerobic or static/strength training; if it is dynamic, should it be constant or interval? For example, it has been shown that high-intensity interval training after only two sessions has similar effects on speeding the oxygen uptake kinetics than traditional constant intensity training. This suggests a rapid upregulation of oxidative enzymes and/or changes in peripheral oxygen delivery (24). Another important factor is that at the limit of tolerance, the muscles of patients with COPD are not exhausted and are still capable of presenting significantly higher muscle force relative to the pre-exercise level (25), indicating that high-intensity (higher than peak work rate) exercise is possible in these patients. However, exercise tolerance characteristically is determined by ventilatory/flow limitation, therefore it is not possible to maintain high-intensity exercise, unless the high-intensity periods are limited in time preventing the minute ventilation to reach its ceiling (26). Regardless of the type of training, the physical and health-related condition of the patient determines the mode of delivery, the expected clinical benefits and whether the facility of choice should be inpatient or outpatient (27).

There is a variety of testing conditions that is being used in evaluating the physical performance of the patients (28). Some of these field tests are characteristically self-paced (6-minute walk test), while others are externally paced and are very similar to the traditional cardiopulmonary exercise test conditions. The self-paced tests do not allow conclusions as to the exercise limiting symptoms and factors but can be useful to judge the habitual walking speed or exercise intensity. These tests are of limited value in assessing both the activity level and the effectiveness of therapeutic interventions, therefore cannot reliably be used for that purpose (29). It is important to emphasize that only tests that are conducted to the limit of tolerance (subjective or objective limit) are suitable for measuring the extent of changes in exercise tolerance and that only those methods that are recording gas exchange during the test are supporting the assessment of physiological improvements. A variety of tests and test modalities are available (28).

The pathophysiology of chronic obstructive pulmonary disease affects both sides of the heart. Increased pulmonary vascular resistance leads to increased right ventricular afterload, elevated pulmonary arterial pressure eventually leading to increase in ventricular volume. Through ventricular interdependence this causes compromised diastolic function of the left ventricle, leading to diastolic dysfunction (30). On the other hand, the higher right ventricular pressure causes systolic overload and failure of the right ventricle (30–32). Therefore, pulmonary disease coexists with cardiac dysfunction, which further complicates the mechanisms and effects of rehabilitative interventions.

In the next issues of this journal, we will publish a series of reviews covering the physiology of muscle dysfunction and effects of training, exercise limitation, exercise testing, and field testing modalities. They will cover the presence and effects of cardiovascular co-morbidity in the form of heart failure in COPD and will also cover the practice and delivery of an effective PR program including measures of physical activity and intervention.

Disclosure statement

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