



Role of pulmonary rehabilitation in chronic obstructive pulmonary disease - a historical perspective

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Abstract

Introduction. Pulmonary rehabilitation is known as an effective therapy for patients with chronic obstructive pulmonary disease (COPD). This article is a brief introduction into the history of medical and pulmonary rehabilitation, presenting the evolution of applied therapies and methods from ancient to present times. It also highlights the role of physical effort in the prevention and treatment of lung diseases, with special consideration to COPD.

Methods. For this literature review, the international databases Medline and Scopus were used to identify relevant articles, between January 1981 to December 2021; eighty articles were considered: thirty-six reviews, eight original research and six general articles which met the criteria for inclusion. A total of thirty references were excluded because they were not relevant.

Results. Available published data suggest a rich history of rehabilitation reaching for thousands of years even though it was developed as a medical branch only in the 20th century. Pulmonary rehabilitation is currently an important component of the management of COPD patients, with a positive impact on symptoms, frequency of exacerbations, severity and mortality rates.

Conclusions. Even though this type of intervention is known to be beneficial for this type of patients more studies need to be conducted in this field.

Keywords: pulmonary rehabilitation, COPD, physical therapy

Introduction

Pulmonary rehabilitation is currently a complex and multi modal therapeutic system with clear benefits demonstrated by evidence-based research at least for some respiratory conditions. Its proven efficacy explains why various rehabilitation techniques are adopted in widely accepted standards of care - such is the case of chronic obstructive pulmonary disease (COPD).

Still, we should not forget that rehabilitation in general and respiratory techniques were being developed before the scientific method emerged and was implemented in the medical field; some elements remain in use today even if

the principles on which they were based were refuted in modern times.

Along these lines we consider of potential interest to provide a short review of available data on respiratory rehabilitation from a historic point of view and focusing on obstructive respiratory disease.

Aim

The aim of this review was to conduct a brief introduction into the history of medical and pulmonary rehabilitation, presenting the evolution of applied therapies and methods from ancient to present times and also to highlight the role of physical effort into

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the prevention and treatment of lung diseases, with special consideration to COPD. Another purpose was to explore the beginning of pulmonary rehabilitation in Romania.

Methods

This systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines [1]. No ethics committee approval was deemed necessary considering the bibliographic nature of this study.

Search strategy

A comprehensive literature research was conducted to present the evolution of applied therapies and methods from ancient to present times and also to highlight the role of physical effort into the prevention and treatment of lung diseases, with special consideration to COPD. For this literature review, the international databases Medline or Scopus database were searched between January 1981 to December 2021, using keywords for the relevant literature. The following **search keywords**: “copd history”, “pulmonary rehabilitation”, “role”, “impact”, “mortality”, “effectiveness” and “exacerbation” were used separately or in combination. The results were limited to articles written in English.

Eligibility criteria

To be eligible for the analysis, studies had to meet the following criteria: (a) to contain information about the use of pulmonary rehabilitation; (b) to contain information about important personalities in this field; (c) to assess the usefulness, the role and the impact of PR in COPD.

Data extraction

The initial screening for the identification of potentially eligible articles was performed by two independent readers (E.I.S. and I.B.) by an initial screening of the databases considering the title and abstract of all identified references. After the relevant literature was collected, each article was analyzed and read in detail to identify and extract the discussions.

Results

Literature search outcomes

The initial literature search retrieved a total of 100 potentially eligible articles. However, only 80 titles and abstracts were screened as 20 were found to be irrelevant for the chosen topic. Of the 80 articles left, 30 articles were further excluded as they did not meet our eligibility criteria (mainly not covering COPD rehabilitation or not available in English). Finally, 50 articles were included into the analysis. Figure 1 presents the flow chart showing the research literature strategy to identify the eligible studies.

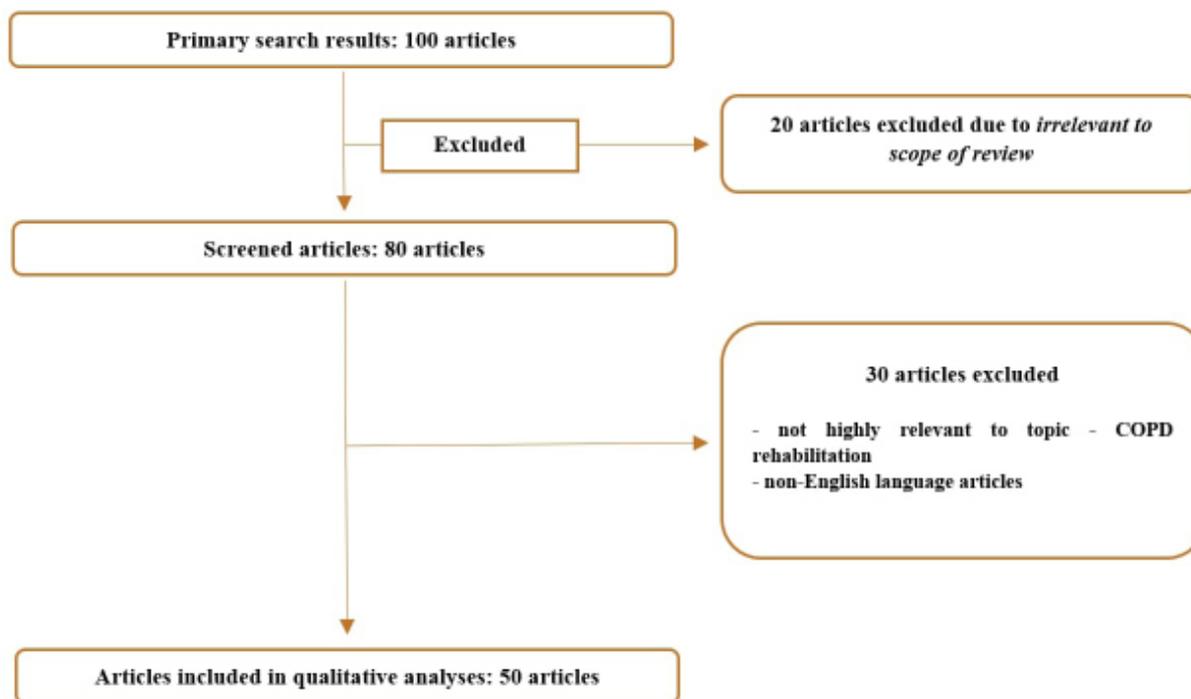


Figure 1. Flow chart showing strategy to identify eligible studies.

Medical and pulmonary rehabilitation in ancient times

Physical medicine and rehabilitation is a medical specialty focused on prevention, diagnosis, rehabilitation and therapy for patients who face functional limitations resulting from injuries, diseases or malformations. The word “therapy” comes from the ancient Hebrew word „*refua*” which means healing [2]. Although rehabilitation as a medical branch has been developed from the beginning of the 20th century, for thousands of years the peoples of Asia have resorted to exercise in order to maintain and promote health. They built pathophysiological theories based on local philosophical or theological currents such as Qigong and Tai Chi. Although these theories have a questionable physiological value, there are data suggesting positive health effects. Basically, the first “therapy” through movement was born consciously or not, with the appearance of human beings on earth and their need for adaptation. Humans have constantly tried to find means to alleviate the physical or spiritual suffering, in their archaic faith these two states being interdependent. In addition to prayers, traditions or customs dedicated to divinity, man discovered various postures that had the effect of reducing physical pain and found specific positions for concentration and meditation which helped stabilizing and coordinating the rhythm of his breathing. From this perspective, some components of pulmonary rehabilitation have been part of medical care for centuries.

Thousands of years ago, the ancient Chinese used a series of therapeutic postures and movements collectively called martial arts (Kong Fu). This practice was used to relieve pain, correct spinal deviations or as post-surgery therapy, while having a philosophical and spiritual meaning within their culture [3]. The positive effects of martial arts practice on cardiorespiratory function and muscle strength are demonstrated today. Also, aerobic capacity as well as maximum muscle strength, speed and endurance to exercise are further improved among those who practice Kong Fu compared to other types of contact sports (such as Tai Chi, Tai Kwando) [4].

The idea of recovery and rehabilitation may be found in the holistic practices of ancient times such as *Ayurveda* - the name given to the corpus of medical practices developed in India over 5,000 years ago, probably one of the oldest known medical systems [5]. Its theoretical basis is considered to have influenced the Japanese, Chinese, Arab, Greek and Roman medical systems, too. *Ayurveda*, which means *life* or *longevity* in Sanskrit, has its roots in *Vedas* philosophy, which means *knowledge* [5]. In the original text of *Vedas*, in ancient India where the oldest religious scriptures of Hinduism are found, dating to about 3000 years ago, there are mentions of practical education about care and hygiene of individuals, with various descriptions of anatomy, physiology, surgery and the use of plants, combined

with ethics and spiritual (moral) activity, also prevalent talk of recommended therapeutic exercises in chronic rheumatism and other diseases [4,5].

New neuroelectrophysiological studies on meditative breathing (*Dan Tian Breathing*) revealed its association with a relaxed state or with a state of enhanced awareness (or enhanced consciousness). Such exercises induce the brain in a relaxed state and improve the performance of individuals, preventing distraction, allowing them to remain focused on tasks, and to cope with the stressful work demands in a relaxed and flexible manner. Clinical observations and empirical evidence suggest that meditative breathing has a beneficial effect on mood disorders such as depression and anxiety, and cognitive problems related to brain disorders (epilepsy, autism spectrum disorders) [6]. Similar approaches and concepts have been developed at a geographical and temporal distance - in modern times breathing techniques have been successfully used to treat not only functional disorders but also respiratory conditions such as asthma (although mental states may act as triggers). While of minor interest today, techniques such as Buteyko breathing must be mentioned.

It is accepted that the basis of science and the study of physiology, anatomy and psychology were developed in ancient Greece, aiming to find the source of diseases and to enhance human health. The Greeks developed the study of physical exercises, like prophylactic and therapeutic gymnastics, because they believed that mental and physical health are interrelated. They also believed that the body and mind must be in harmony, and understood that sport and gymnastics are essential to this goal. Motor activity, exercises and even sports were considered very important in ancient Greece, as evidenced by the Olympic Games - hence the famous phrase “*healthy mind in a healthy body*” [2,3]. The Greek physician *Herodicus* (5th century BC), considered by some scholars Hippocrates’s tutor, is the first person in the history of medicine to combine, physical exercise and sport with medicine. He is also the first who developed a system of gymnastic exercises for the prevention and treatment of diseases [7].

Hippocrates (figure 2) (c. 460 - c. 370 BC), the most prominent figure in the history of medicine, focused on the “natural” treatment of diseases and approached medicine as a rational discipline and not just theocratically as his predecessors. He pointed out the cause of illnesses as due to the environment and emphasized the therapeutic importance of psychological factors, nutrition, lifestyle, independence of mind, body, and spirit, and the need for harmony between individual and the social and natural environment. This credo is reflected in the Hippocratic oath. Hippocrates founded the art of observation, which involved using all the senses to consult the patient (sight, hearing, smell, touch, and judgment) [3,8].



Figure 2. Hippocrates.

Medical recovery after the emergence of Christianity

The Christian era produced a change of mentality, focused on encouragement, preventive, solidarity, sympathy and support between individuals. People with disabilities (deaf, blind, lame, lepers) were often described in the gospels, becoming the subject of miraculous healing. Once they were physically and spiritually rehabilitated, they could once again participate in social and civic life of the city [8].

In the Middle Ages, the practice of regular exercise as well as adequate rest adapted to the state of health remained generally unorganized. The philosopher and physician *Moses Maimonides* (1138-1204), a Sephardic Jew, born in Córdoba, Spain, emphasized the Talmudic principles of healthy habits consisting of exercise, as well as diet, as a preventive medicine. "*Treatise on Asthma*" are part of Maimonides' writings, where through a logical and systematic approach, he describes how to diagnose, prevent and treat asthma. Maimonides describes different remedies for asthma depending on its severity. The practices he describes aim to cleanse the lungs, ease breathing and eliminate coughs. He states that: "*the first thing to consider ... is to ensure clean air, fresh water and a healthy diet*" [9]. Clean air is described in detail: "*the city air is stagnant, cloudy and dense, a natural result of large buildings, of narrow streets, of the garbage of its inhabitants ... a wide open house should be chosen ... better living spaces, to be located on a higher floor ... where it can benefit of ample sunlight exposure... toilets should be located as far away as possible from living areas. The air should be kept dry at all times by sweet flavors, fumigation and drying agents. Concern for clean air is the most important rule in maintaining the health of one's body and soul*" [9].

Between 1187-1190 he wrote in Arabic a content of 1500 aphorisms describing many medical conditions,

published in 1970 in English, "*The Medical Aphorisms of Moses*". This book provides a detailed description of medicine as practiced in the thirteenth century in most civilized regions of the West, held at that time by the Arabs [2,10].

During the Renaissance, between the 15th and 16th centuries AD, the progress of the study of human anatomy and the systematic understanding of the medical role of physical activity and exercise were characteristic of this period, and medical rehabilitation became a distinct discipline. Among the most important schools that promoted an active life are those of: *Méndez, Castiglione, Mercuriale, Paré, Joubert, Cagmatis, Cogan, Leonardo and Michelangelo* [11].

The first book of physiotherapy (figure 3) is considered to have been written by the doctor *Cristóbal Méndez* (1500-1553), born in Huelva, Spain. He spent much of his life, respectively 15 years, in Mexico, being investigated by the Spanish Inquisition because he was trying to decipher the zodiac inscriptions. Back in Spain, he wrote a 72-page text entitled "*Libro del Exercicio Corporal*" (1553) in which he defined exercise as "*a voluntary movement in which breathing becomes rapid ... and frequent.*" He concluded that exercise is beneficial because it creates heat, helps digestion and gets rid of excess body mass. "*Exercise was invented and used to cleanse the body when it is too full of harmful things*" [11].

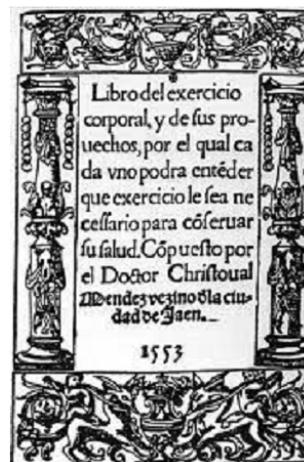


Figure 3. Cover of the book of physical exercise and its benefits, by Cristobal Mendez, 1553.

An innovative work on human anatomy at the time was written by the Flemish anatomist *Andreas Vesalius* (1514-1564). Published in 1543, the book "*De Humani Corporis Fabrica Libri Septem*" placed more emphasis on illustrations than text, contained drawings of several organs, so as to allow the creation of three-dimensional diagrams by cutting organs and pasting them on cut figures [8,12].

During the late Renaissance, the Italian physician and philologist *Girolamo Mercuriale* (1530-1606), studying literature and medicine, had access to the great libraries of Bologna, Padua and Venice. In 1569 he printed his landmark text entitled “*De Arte Gymnastica*” (Art of Gymnastics) considered the first book on sports medicine, where he provided explanations of the principles of physical therapy used as a preventive, therapeutic intervention, aimed at people with disabilities, and old patients, as a tool for rehabilitation [2,13].

The seventeenth century is considered the century of the “scientific method” because during this period, the systematic approach to the study of biological phenomena became predominant in the Western world. The scientist contemporary to that period emphasized the importance of approaching empirical experiments, mathematical concepts, and explanations only through the physical laws of nature. Physiologist and mathematician, *Giovanni Alfonso Borelli* (1608-1679) was one of the most charismatic and brilliant scientists of his generation in Europe. He analyzed muscle contraction, heart function, blood flow, nerve transmission, lung function and many other biological problems using modern scientific methods [2,14].

The first description of pulmonary emphysema

COPD is probably not a new condition. In the past, doctors may have used different terms to describe what we knew today as COPD. The evolution of knowledge about COPD and its components (emphysema, chronic bronchitis and asthmatic bronchitis) covers over 200 years. Some of the earliest references to pulmonary emphysema include the description of the Genevan physician *Théophile Bonet* (1620-1689) about “*bulky lungs*” of 1679 [15,16].

The Italian anatomist *Giovanni Battista Morgagni* (1682-1771) considered the father of pathological anatomy, described the pathology of the respiratory system, the hepatized lung in pneumonia, the fibrinous bronchitis and the pulmonary tuberculosis, which remains relevant to these days. In 1769 he reported 19 cases in which the lungs were “turgid”, mainly due to air pollution [15].

The British physician *Matthew Baillie* (1761-1823) is known for his illustrations of the emphysematous lung. In 1793 he published a book entitled “*The Morbid Anatomy of Some of the Most Important Parts of the Human Body.*” The work consisted only of text, but in 1799 he published another work, “*A Series of Engravings Accompanied with Explanations*”, which illustrates the morbid anatomy of some of the most important parts of the human body, providing 206 illustrations of different pathological types which were previously described in the 1793 book. Baillie is credited with being the first to produce an illustrated systematic textbook of morbid anatomy and probably the first to illustrate pulmonary emphysema and the composition of large vessels (Figure 4) [15,16].

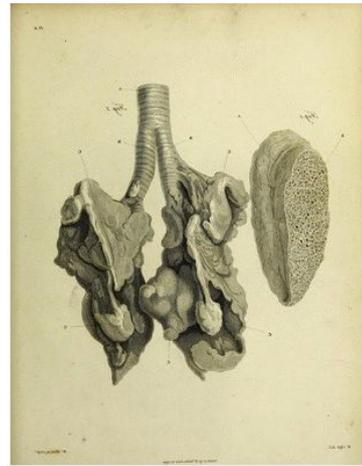


Figure 4. Section of lung of Samuel Johnson.

The beginning of the clinical understanding of chronic bronchitis as an associated component of COPD can be attributed to the English physician *Charles Badham* (1780-1845) in 1814. He used the word “cough” to describe the symptoms of chronic cough and mucus hypersecretion [15]. The component of pulmonary emphysema was described in detail by the French physician and musician *René Laënnec* (1781-1826) in 1821. In his paper “*Treatise on Thoracic Diseases*” he described the emphysematous component of lung disease and the combination of bronchitis and emphysema. Because smoking at the beginning of the XIX century was not a widespread habit among the population, Laënnec identified air pollution and hereditary as risk factors among the causes for COPD development [16,17]. Having the ability to sculpt various wooden objects, especially flutes for singing, he invented, initially in a different form, the stethoscope in 1816.

The main tool in diagnosing COPD, the spirometer, was invented by the English surgeon *John Hutchinson* (1811-1861). He invented a calibrated bell, overturned in water, to be able to capture and measure the volume of exhaled air from a completely swollen lung. He coined the term vital capacity, meaning life capacity, a concept that later became known as FEV₁ (Forced expiratory volume in 1 second). 100 years later, *Robert Tiffeneau* (1910-1961) would build a comprehensive diagnostic tool in the diagnosis of COPD [18].

Pulmonary rehabilitation in the contemporary period

The concept of respiratory recovery was imposed worldwide after the Second World War, first in the assistance of restrictive and postoperative syndromes and only after 1950 in the assistance of obstructive syndromes [19]. In the twentieth century, COPD clearly became a major public health problem. Initially, patients were advised to avoid dyspnea caused by physical activity, just as today patients

with coronary heart disease are advised to avoid activities that cause angina pectoris. These recommendations were part of the management of the disease at that time. Contrary to these opinions, the doctor *Alvan L. Barach* (1895-1977) did not agree with this approach. Barach is considered a pioneer of oxygen therapy in research of respiratory diseases. He created the first “tent” (figure 5) with oxygen in 1926 and also developed the first continuous method of aerosol therapy, and later became the leading developer of devices that allow people with chronic respiratory problems to exercise with small oxygen-containing devices [20].



Figure 5. The first practical oxygen tent by adding ice for cooling and soda-lime for carbon dioxide absorption, 1926.

Affiliated with Columbia University in New York, he is credited with the statement that COPD patients should strive to be more active. He had a long medical career, between 1920 and 1970 and a rich publishing career, totaling over 300 articles, some of them (128) indexed and still found in PubMed [20]. In a 1926 publication he described the effect of oxygen in reducing shortness of breath in pneumonia patients. In 1936 he described the use of heliox to relieve dyspnea in asthma and emphysema. In 1945 he published a description about the benefits of penicillin in treating pneumonia. In the 1950's he worked on the development of portable oxygen systems for patients with emphysema [21]. In a 1952 paper he wrote the following: “*In 2 patients with pulmonary emphysema in whom exertional dyspnea was relieved during oxygen inhalation, an exercise program was established, followed visibly by increased exercise capacity without oxygen... the progressive improvement of the ability to walk without dyspnea suggests that a physiological response similar to a sports training program may have been produced*” [22,23].

The pulmonologist *Thomas L. Petty* (1932-2009) (figure 6) is considered the most important doctor in the history of respiratory rehabilitation, due to the importance of his original contributions and their practical relevance. He was one of the first specialists to organize a lung rehabilitation program and showed the beneficial effects of long-term oxygen therapy in COPD pathology. He

published original investigations involving new devices, including fans, monitors and equipment for oxygen and aerosol therapy [21,23]. Working at the University of Colorado, he established and coordinated an outpatient pulmonary recovery team in the 1960s. He conducted several studies related to drug therapy in tuberculosis and the long-term sequelae of this disease [21]. In 1969 he published “*A Comprehensive Care Program for Chronic Airway Obstruction,*” in which he notified on the beneficial effects of pulmonary rehabilitation programs for patients recently discharged from the intensive care unit and for those with COPD [24]. *Petty and his medical team estimated that the results obtained in 94 patients out of 124 included in a rehabilitation program made them have a better tolerance to effort, a reduced number of days of hospitalization and earlier return to work* [17,21]. As a consequence of these amazing results, rehabilitation programs based on Petty's model began to be established worldwide, and many researchers reported new rehabilitation programs with encouraging effects at various international congresses. In 1974 the American College of Chest Physicians formulated a definition of pulmonary rehabilitation, and in 1980 the American Thoracic Society (ATS) issued an official provision recognizing the effectiveness of exercising as an “essential” component of pulmonary rehabilitation [17,21].



Figure 6. Thomas L. Petty in his office at the University of Colorado Medical Center.

In the 1980's, there was some skepticism about lung rehabilitation, arguing that patients' exercise tolerance is limited by lung condition, so exercise cannot improve lung function because the intensity cannot exceed the critical training threshold. In 1999, a group of muscle biologists authored an extensive scientific paper presenting evidence that the ambulatory muscles of COPD patients are weakened and argued that these patients need to improve their muscle function, especially those involving locomotion [23]. After the 2000s, understanding the effectiveness and benefits

of physical training became convincing, as it was shown that improving muscle function through rehabilitation directly improves exercise tolerance. In a 2005 paper, Professor Janos Porszasz together with a team of researchers had shown *“the mechanism by which recovery training reduces dyspnea - at a certain level of exercise, it reduces the respiratory rate, thus allowing more time for exhalation, which decreases the dynamics of hyperinflation and therefore would improve resistance to submaximal exertion”* [23,25].

The twentieth century is the century in which information technology has spread rapidly, having an impact on all areas of activity and daily life. In the medical field, with the help of studies and research, this medical branch has begun to develop worldwide, in a scientific and rigorous manner. Over time, special techniques and devices used in the recovery of lung patients have been developed, and the emergence of respiratory recovery centers, clinics and services are now widespread throughout the world.

Pulmonary rehabilitation and COPD: concepts, programs and importance of rehabilitation in current pneumology practice

The first time that physical therapy was used as a way to help pulmonary patients was during the First World War, when a British nurse applied this type of exercises on soldiers that suffered traumatic respiratory complication. The nurse name was Winifred Linton and after the war she continued applying these methods to pulmonary patients and also to teach others at the Royal Brompton Hospital in London. In the United States the use of airway clearance techniques was started by the polio epidemic, during 1940's. As mentioned before, the first definition of pulmonary rehabilitation was draw up in 1974. Since then, due to the results obtained and the improvement of lung rehabilitation techniques, the definition has undergone multiple changes and additions. In 1979, was tried to redefine the term “respiratory rehabilitation” and to set new objectives. In 1981, was established a logical hierarchy of the stages included in a respiratory recovery program. In 1986, Professor Barry J. Make of Boston University School of Medicine wrote an article entitled *Pulmonary Rehabilitation: Myth or Reality?* in which he revises the previous definition and emphasizes the important role of respiratory rehabilitation [26]. In 1994 the NHLBI (National Heart, Lung, and Blood Institute) published a new definition where for the first time the role of the *“interdisciplinary team of specialists”* is specified in order to *“acquire and maintain the maximum level of independence and functionality of the patient”*. In 1999, the term “pulmonary rehabilitation” (PR) supports a new definition, this time referring to *“individually adapting and designing to optimize physical performance”* of respiratory rehabilitation programs. In 2006, ATS adopted a new broad definition, which is still valid today. As a novelty, it is

specified that pulmonary rehabilitation is *“an evidence-based, multidisciplinary, and comprehensive intervention”* [27]. The current definition was given in 2013, it also emphasizes the prophylactic behavior, *“promote long-term adherence to health-enhancing behaviors”* [28]. In this last statement, pulmonary rehabilitation was defined as a comprehensive program, which included a team of professionals who worked together for the benefit of the patient. The multidisciplinary team included: a physician, a pulmonary and a physical therapist, nurses and other staff. Although the current definition of pulmonary rehabilitation remains relevant today with a few additions. The emergence of the COVID-19 pandemic made ATS to design new *“models that aim to enhance access and uptake, including telerehabilitation and home-based models”* [29,30].

The role of rehabilitation programs for COPD patients was scientifically proven by the studies conducted in this field during the years; the results show that rehabilitation programs improve the quality of life of these patients by alleviating symptoms like dyspnea and also by reducing anxiety and depression. The exercise training conducted during rehabilitation programs has a positive impact on the walking distance, the tolerance of the patients to exercise and on the physical function of patients with mild and severe COPD. Another important role of pulmonary rehabilitation is the positive impact it has on the exacerbation of COPD, because it helps patients overcome the event and also increase the time interval between the appearance of these episodes in the evolution of the disease by applying different type of methods of rehabilitation [31]. PR seems to also have an impact on the mortality rate of COPD patients, impact shown also in a study conducted by Özmedir et al. The authors assed the number of COPD patients that were referred and underwent a PR program, in Turkey, between 2008 and 2016, and also the general annual mortality rates which were lower in the patients included in a PR program in 2008 (6.2% - 11.1% vs 52.8%) [32].

The British Thoracic Society published a Pulmonary Rehabilitation program in 2013 in the Journal of the British Thoracic Society stating that PR should be offered to all patients suffering of COPD with the aim to improve the health status and the quality of life of these patients, by decreasing the intensity of the symptoms and the need for hospitalization [33]. In 2017 The Lung Foundation Australia and the Thoracic Society of Australia and New Zealand published a Pulmonary Rehabilitation Guideline, with the same recommendations that COPD patients should be recommended to follow a PR program [34]. In the European Lung White Book published by the European Respiratory Society the subject of PR is also addressed and recommendations are made [35]. The 2020 GOLD (Global Initiative for Chronic Obstructive Lung Disease) guideline, which is a reference point for COPD treatment, also shows the importance of pulmonary rehabilitation for

these types of patients, and states that rehabilitation is the most useful therapeutic strategy used to improve shortness of breath, exercise tolerance and health status [36]. The interest showed for this field over the years highlights the importance of PR for this type of patients.

The essential components of pulmonary rehabilitation programs, are defined by ATS in an article published in 2021. During the first visit the patient assessment is conducted, and includes: assessment of the patients by a health care professional, performance of an exercise test and a field exercise test, measurement of the quality of life, quantification of dyspnea, evaluation of nutritional and professional status. After the first visit the program components are chosen taking in to account the information about the patient obtained during the first visit, the multidisciplinary team will conduct endurance and resistance training. During and after the program the quality assessment of the exercise prescribed is performed. The duration of such a pulmonary rehabilitation program is between 4 weeks to 20 months, with an average of 8 weeks, depending on the stage of the disease and the characteristics of each patient [30].

A key part of a COPD rehabilitation program is thought to be the education of the patient and this is why a special importance was given to it and every patient included in this type of programs were asked to participate in courses or were given information's regarding the disease, the importance of treatment and the way devices should be used. In 2021 ATS stated that education remains an important part of COPD PR even though studies were not conducted in this domain and the most beneficial way to provide information to patient has to be determine. It is important to provide these types of information because in this way changes in behavior and the control of the disease can be obtain [30]. Long et al, studied the role of health coaching in improving the quality of life of this category of patients in a systematic review and meta-analysis, and showed that health coaching should be considered as a candidate intervention for improving quality of life and also shown that it has an impact on hospital admissions, reducing the numbers of readmissions [37].

Cardiopulmonary test should be conducted at the inclusion of patients in PR because it helps assess the influence of the cardiac and respiratory system on the exercise tolerance of a patient, especially because COPD patients can have underlying diseases. After the tests are performed the multidisciplinary team of the PR can establish the most helpful exercise training [38].

Most studies on the effects of physical training in COPD patients focus on whole-body endurance exercises, such as treadmill walking or using of a cycle ergometer. These exercises should be performed for a minimum of 20 minutes with an intensity of 60% or more of the maximum intensity tolerated by the patient. However, it is not possible for all COPD patients to follow these recommendations,

due to the stage of the disease, associated diseases, etc. In their case, other types of exercises are used, such as Nordic walking for those individuals who have a relatively preserved tolerance to exercise or neuromuscular electrical stimulation (NMES) for those patients with a high degree of dyspnea or even mechanically ventilated patients [39,40]. Santos et al conducted a study comparing the effects of different intensities aerobic exercises in COPD patients (60% vs 80% maximum work rate) showing that exercises conducted with higher intensity than 60% W max did not have any additional benefits, regarding symptoms control or exercise tolerance [41].

The results of a meta-analysis conducted by Ryrso et al, showed that the initiation as soon as possible (during or in the first 4 weeks after hospitalization) of a respiratory rehabilitation program in patients with COPD hospitalized for exacerbations of the disease, causes a decrease in mortality, number of days of hospitalization and number of readmissions [42]. A study also conducted in patients with acute exacerbation of COPD by Lioa et al concluded that pulmonary rehabilitation improves symptoms such as dyspnea and cough, and also increases exercise tolerance and decrease sputum expectoration [43].

Another important part of the respiratory rehabilitation program is represented by the supportive strategies, like psychotherapy and nutritional advice. Nutritional advice can also involve prescription of nutritional supplements or even pharmacological treatment, part attributed to the nutritionist in the multidisciplinary team. Its role has been shown especially in patients suffering from weight loss or muscle loss. The effectiveness of targeted nutrition was analyzed by Bool et al in a study conducted on 81 patients diagnosed with COPD with low muscle mass included in a PR program. The results of the study showed that Specific nutritional supplementation has a positive impact on nutritional status, inspiratory muscle strength and on the physical activity of these patients compared to placebo [44]. Psychotherapy is also a well-known supportive strategy, because COPD patients struggle with depression and anxiety. The results of a meta-analysis conducted by Farver-Vestergaard et al, support the use of psychosocial intervention in patients diagnosed with COPD as a multidisciplinary respiratory care tool because of the potential it has to improve both psychological and physical outcomes [45].

Because the underlying disease for which rehabilitation is performed is a condition with gradual evolution that involves the progressive loss of respiratory function, the repetition of the rehabilitation program may be considered depending on the needs of patients. An important aspect to consider is that at least 1 year should pass after the last PR if repetition is needed [34]. Blervaque et al. conducted a 5-year cohort study in which patients diagnosed with COPD how underwent a pragmatic multidisciplinary PR maintenance program with a duration between 1 and

5 years and the results showed that the less severe COPD patients included in this group showed significant PR benefits at 4 years for the 6-min walking distance and the Health-Related Quality of Life and at 5 years for the modified Medical Research Council. Also, in the PR group the 5-year survival probability was found to be higher [46].

As stated above rehabilitation is an important component in the management of COPD patients, but unfortunately 50% of patients diagnosed with this disease are not willing to participate in such a program and 30 to 50% give up attending after a few sessions. Debilitating symptoms and encountering difficulties in transportation to centers or hospitals are the most incriminated reasons [31]. In order to create more accessible programs for different type of patients, researchers are trying to find new ways to make patients with COPD more adherent to rehabilitations programs by using all the technologies available today. This is why telerehabilitation programs started to be implemented worldwide and studies are conducted to assess the efficacy of this type of rehabilitation.

Pulmonary rehabilitation in Romania

Our literature review returned no relevant data on Romanian history of rehabilitation medicine; using alternative sources (medical treatises, medical courses, magazines) we were able to summarize some important milestones.

In Romania, pulmonary rehabilitation is a component part of Medical Rehabilitation, a clinical medical specialty which prior to 2013 was called *Recovery, Physical Medicine and Balneology*. According to the medical practice guide for the specialty of *Recovery, physical medicine and balneology*, medical rehabilitation is defined as the independent clinical medical specialty responsible for the prevention, diagnosis, treatment, and management of rehabilitation of people with disabilities and comorbidities at all ages. This specialty is also responsible for the physical and cognitive performance of such patients, as well as increasing their quality of life. Its purpose is to improve and restore the functional capacity and to ameliorate symptoms in people with physical disabilities. Among the objectives of rehabilitation can be listed: improving the quality of life, reducing dyspnea, increasing exercise tolerance, reducing anxiety, increasing joint mobility, increasing muscle strength, psychosocial reintegration, etc [17,47].

Medical rehabilitation as a concept emerged in Romania in the 1920's but dedicated medical establishments sprung into existence in the second half of the 1970's. The demand for rehabilitation services was only partially satisfied in an erratic and inconstant way. The existence of medical resorts such as Felix, Herculane, Govora, Tuşnad, Olăneşti, Slănic Moldova had a positive impact and helped develop services and even a certain experience and tradition in the field of recuperative medicine. In the seventh decade

of the XXth century local public health leaders in Iasi and Cluj advanced the idea of founding rehabilitation hospitals; in Iasi construction commenced in 1974 - three years later the first patients were admitted.

The first respiratory rehabilitation treaty was drafted by Prof. Tudor Zbenghe in 1983 to formalize such approaches. It must be mentioned that respiratory rehabilitation and physical therapies have been part of standard of care in respiratory medicine from the beginning of pneumology and thoracic surgery: simple recruiting techniques to prevent postoperative atelectasis, respiratory gymnastics to prevent fibrothorax, postural drainage and tapotage for bronchiectasis and pulmonary abscesses, nutritional supplementation and physical exercise for tuberculosis are but few examples of tools that have been used during the twentieth century for pulmonary disorder in Romanian respiratory centers. Halotherapy must be mentioned as a trademark eastern European respiratory therapy (a situation explained by the large salt deposits in the area) - known and used for at least two hundred years. This approach was first backed up by anecdotic evidence and popular beliefs, but recent high-quality data supports the use of inhaled saline by products for suppurative pulmonary disorders [48]. It should be noted that doctors in Romania have been closely concerned with this branch of medicine with all the syncopes and obstacles imposed by the times. An illustrious name is that of Prof. Dr. Iuliu Moldovan (1882-1966) from the Cluj Faculty of Medicine, he discovered and used therapeutic reticulin, with beneficial effect for the treatment of human patients with allergic disease, some moderate vascular alterations but especially to prevent different forms of anaphylactic shock [49]. Another important name of Romanian medicine is that of Prof. Dr. Octavian Fodor (1913-1976), who made some original contributions for that period, published in his treatise on internal medicine in 1972 [50].

In Romania, pulmonary rehabilitation programs are carried out according to international guidelines and standards, Iaşi and “Grigore T. Popa” University of Medicine and Pharmacy being a center of prime importance in this field. Over 1000 patients included annually in the lung recovery program, of which over 500 have COPD. In Iaşi, the cardiopulmonary recovery clinic was founded on the initiative of Prof. Dr. Ioan Lungu, starting with 2008 it split in two medical directions. Nowadays, in the Respiratory Recovery Clinic of the Clinical Recovery Hospital in Iaşi, approximately 500 patients with COPD are treated annually out of a total of 800,000 patients with COPD, the rest being patients with asthma, chronic bronchitis, pulmonary emphysema, bronchiectasis, bronchopulmonary neoplasm, sequelae of tuberculosis, idiopathic pulmonary fibrosis etc. Respiratory rehabilitation is practiced and promoted also in other university centers, such as Bucharest, Timișoara, Craiova, Cluj-Napoca, Constanța, Oradea, Braşov, Sibiu or other county hospitals [17].

Conclusion

Various respiratory physical techniques have been employed since ancient times to achieve or to maintain health drawing from direct observation and traditional and religious/philosophical practices and teachings. While lacking a theoretical basis some of these practices proved to be effective and withstood the test of time being still employed today in various refined forms.

Modern scientific approaches validated some traditional respiratory rehabilitation practices and consolidated an evidence-based body of knowledge. Wide acceptance and further development of pulmonary rehabilitation was somewhat hindered by a certain lack of standardization and methodology of quantifying the health effects – a difficult task as rehabilitation is frequently intermingled with other therapeutic approaches. At the present moment there is reliable data supporting the role of pulmonary rehabilitation in COPD management and current guidelines strongly recommends its use.

There are few published data relevant to the history of Romanian pulmonary rehabilitation - this topic should be addressed by future research focusing on alternative sources such as medical archives, public annuaries and using the tools of historiography. Speleotherapy and more specific halotherapy may be mentioned as a Romanian/Eastern European particular contribution to respiratory rehabilitation armamentarium.

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