Igiene e Sanità Pubblica 2025; 98 (5)

Management of rehabilitation timing in the care of patients with COPD: a challenge for public health.

Annamaria Servadio[1], Matteo Tamburlani[2], Tiziana Trequattrini[3], Simona Rossi[2], Anna Cerrito[2], Cosetta Donato[2], Mariarita Loporchio[4], Laura Sanrocchi[5], Cristian Mendico[6], Giovanni Galeoto[7], Maria Cristina Zappa[8]

Affiliation

[1]Director of the Rehabilitation Health Professions Unit, ASL Roma 2;

[2]Physiotherapist, Rehabilitation Health Professions Unit, ASL Roma 2;

[3]Head of the Local Pulmonology Unit, ASL Roma 2;

[4]Physiotherapist Coordinator, COPD Physiotherapy Clinic;

[5]University of Rome Tor Vergata, Master's Degree Course in Rehabilitation Sciences for Healthcare Professions;

[6]Institut de Mathématique de Bourgogne, UMR 5584 CNRS, Université Bourgogne Europe, 21000 Dijon, France;

[7]Researcher, University of Rome La Sapienza, Department of Human Neuroscience;

[8]Director of the Transmural Pulmonology Unit, ASL Roma 2.

Keywords: *COPD, pulmonary rehabilitation, exacerbation, rehabilitation timing.*

Abstract

Introduction: The management of chronic and multiple chronic conditions is a major challenge for public health. The pilot study aims to develop a mathematical model which, together with a telemonitoring protocol, will ensure the reprogramming of chronic patients in the medium to long term, optimizing waiting lists and, consequently, the quality of the service provided, including through the pursuit of equity and accessibility to the service.

Materials and methods: The study was conducted by the clinical rehabilitation team at the San Felice Polyclinic of ASL Roma 2 between September 2024 and April 2025. Fifty-four patients diagnosed with moderate COPD were recruited and treated, divided into three groups of 18, and were re-evaluated 3, 4 and 5 months after discharge. The patients underwent 20 group respiratory rehabilitation sessions and aerobic training with progressive load on exercise bikes.

Statistical analysis: For each sample of patients, the mean and standard deviation were calculated of the STS and 6MWT recorded at the beginning of treatment (T0) and at the end (T1) of this, at the beginning of the second cycle after the established period (T2) and at the end of the same (T3). To evaluate the effectiveness of treatment with readmission at 3, 4 and 5 months, the average of the test values at the end of the first cycle and at the beginning of the second cycle was considered; the Wilcoxon-Mann-Whitney hypothesis test was used to compare the distributions.

Results: For each of the tests carried out both at admission and discharge, the left extreme and right extreme are lower than those of the other groups. The Wilcoxon-Mann-Whitney hypothesis test shows that the treatment is more effective when carried out 3 or 4 months after the last treatment than when carried out 5 months after the last treatment.

Discussion: The study revealed the importance of initiating comprehensive and individualised pulmonary rehabilitation protocols to reduce the incidence of exacerbations, thus also producing economic and health benefits. Statistical analysis

Igiene e Sanità Pubblica 2025; 98 (5)

confirmed a shared approach to planning long-term readmissions, thus facilitating the management of waiting lists and the staff involved, improving the quality of the service in terms of efficiency and productivity.

Conclusion: In a period of severe crisis for the Regional Health Service, the management of waiting lists ensures the constant pursuit of equitable access to care and accessibility to the service, understood as the ability of a service or environment to be usable without barriers for everyone and to reach the highest number of users with COPD. Telerehabilitation and telemonitoring could represent a great opportunity that can increase the level of enforceability of citizens' right to health, sustainability and innovation of the National Health System.

1. Background

Respiratory diseases are conditions that affect both the lungs and the other parts of the respiratory system involved in gas exchange between the external environment and the bloodstream (1).

Chronic obstructive pulmonary disease (COPD) is a common, preventable and treatable disease characterized by persistent respiratory symptoms and airflow limitation (2). It is caused by abnormalities in the airways and/or alveoli, usually due to significant exposure to harmful particles or gases, cigarette smoke inhalation, and influenced by host factors like abnormal lung development (3).

The WHO estimates that 80 million people suffer from moderate to severe COPD and that over 2 million people die each year mainly from this disease. In Italy, it is estimated that there are about 6 million people affected by this disease, which is one of the leading causes of hospitalization and causes about 20,000 deaths per year, with very high social and human costs (4).

Recent studies have shown that this disease's prevalence is significantly higher in smokers and ex-smokers, in people aged ≥ 40 years and in men, although there has been a recent reversal of this trend due to an increase in female smokers, which will lead to a balance in prevalence between the sexes (3).

Specifically, the prevalence of COPD in smokers and ex-smokers over the age of 40 is approximately 10%, higher in males, and increases with age to over 25% after the age of 80 (5).

Approximately one in two patients with COPD experiences at least one exacerbation (AECOPD) each year, and it is estimated that a single AECOPD event can increase the risk of mortality by 71% (6). These are a serious complication of the disease and have many adverse effects, including a worsening of quality of life and acceleration of disease progression (7); they are therefore an important negative prognostic factor for COPD and also the most common cause of hospitalisation in this type of patient (8).

Early pulmonary rehabilitation (PR) for AECOPD has a statistically significant beneficial effect on readmission rates, 6MWT, Borg score and MRCscale compared to usual care without PR (7).

Therefore, recent guidelines from the American Thoracic Society (ATS) and the European Respiratory Society (ERS) suggest that RP should begin within three weeks of discharge from acute exacerbations of COPD (9).

Igiene e Sanità Pubblica 2025; 98 (5)

Respiratory rehabilitation is one of the most important non-pharmacological therapies, including physical training, improving aerobic capacity, symptoms and quality of life for all degrees of COPD severity (5).

Through the study of the literature, we can affirm that physical activity has a positive effect on exercise capacity, lung function, dyspnoea, muscle strength, fatigue, patient autonomy and quality of life (QoL) (10–12).

This reveals the crucial importance of initiating comprehensive and individualised exercise-based pulmonary rehabilitation protocols in order to achieve the highest possible level of physical, functional and social autonomy and improve the quality of life (QoL) of patients with COPD, as well as reducing the incidence of serious pulmonary and functional complications, such as exacerbations, thus also producing economic and health benefits (13,14).

This study aims to investigate the maintenance of improvements achieved through a respiratory rehabilitation protocol consisting of breathing exercises and aerobic training at 3, 4 and 5 months.

Since the management of chronic and multiple chronic conditions is a major challenge for public health (15), the pilot study aims to develop a mathematical model which, together with a telemonitoring protocol, will ensure the reprogramming of chronic patients in the medium to long term, optimizing waiting lists and, consequently, the quality of the service provided, including through the pursuit of equity and accessibility to the service.

2. Materials and methods

Participants

The observational study was conducted by the clinical rehabilitation team at the San Felice Polyclinic of ASL Roma 2 between September 2024 and April 2025.

Fifty-four patients diagnosed with moderate COPD were recruited. After a treatment of 20 respiratory rehabilitation sessions, the patients were divided into three groups of 18 and were reassessed 3, 4 and 5 months after discharge.

To participate in the study, individuals had to meet the following inclusion criteria: diagnosis of COPD, admission to a respiratory rehabilitation program, minimum age of 18, ability to communicate in Italian and sign the informed consent form for the processing of their personal data. Study participants were informed in advance about the purpose and methods of the study, signed the informed consent form for physiotherapy treatment, and were registered (16).

Compliance with ethical standards

The authors certify compliance with ethical standards by following all institutional and governmental regulations. All procedures were performed in accordance with the ethical standards of the Committee Responsible for Human Experimentation and the Declaration of Helsinki, as revised in 2008. Informed consent was obtained from all participants for inclusion in the study. The relevant documentation was sent to the Ethics Committee on xxxxx. The research involved the analysis of data collected in such a way that individual subjects could not be identified in any way.

Igiene e Sanità Pubblica 2025; 98 (5)

Tools

The following assessment scales were used to analyse endurance capacity:

- Sit-to-stand (STST): this is a physical test that assesses leg strength and endurance by counting the number of times the patient can stand up and sit down in a 30-second period (17);
- 6-minute walk test (6MWT): this is a test used in cardiorespiratory rehabilitation to assess the functional autonomy of a patient with respiratory diseases. The patient is asked to walk along a 30-metre straight line for 6 minutes at their own pace. The therapist notes how many metres the patient has walked in the 6-minute time limit. The test can be stopped by the therapist if the patient shows a high level of fatigue or any other condition that could be dangerous for them. In this case, the metres covered and the time taken to complete the activity are recorded (18,19);
- BORG: this is a tool for assessing perceived exertion. The patient is asked to quantify their perception of exertion with a number from 0 to 10, where 0 is "none" and 10 is "maximum exertion" (20).

All patients were assessed at the beginning (T0) and at the end of the rehabilitation programme (T1). The same assessments were performed at the beginning of the second cycle (T2) and at the end (T3).

Rehabilitation intervention

Patients performed breathing exercises and aerobic training to readapt to exertion.

Breathing exercises were performed in groups. Physiotherapists instructed patients on the exercises to perform, which were related to breathing (inhalation and exhalation) combined with joint movements, such as inhalation combined with shoulder flexion and exhalation combined with shoulder extension, or inhalation combined with both shoulder flexion and knee extension, or exhalation combined with both shoulder extension and knee flexion. All exercises were performed in a seated and standing position.

Aerobic training for readaptation to exertion was performed with a progressive load on a stationary bike. Patients were asked to cycle for 20 minutes with a load of 30/40 watts progressively for the first 10 sessions. For the next 10 sessions, a progressive load of 40/50 watts was set for 25 minutes. The rehabilitation protocol is shown in Table 1. The progression of the aerobic exercise and therapeutic exercise loads was agreed with the Rehabilitation Team based on the heart rate, degree of muscle fatigue and dyspnea reported by the patients.

Timing	**Short-term (1-10 sessions)**	**Medium-term (11-20 sessions)**	**Long-term (follow-up)**
Target	ROM and strength recovery; Thoracic mobility recovery;	Strenght recovery; Stress training.	Return to daily activities.

Igiene e Sanità Pubblica 2025; 98 (5)

	Reconditioning to exertion.		
Number sessions/week	3	3	2
Treatment	- Release of target muscles; - Cervical pumping, stretching of the trapezius, SCOM and scalene muscles; - Therapeutic exercise for ROM of the lower and upper limbs; - Deep breathing and exhalation exercises with pursed lips; - Reconditioning with progressive load on an exercise bike (20 minutes; watts: 30-40); - Muscle strengthening with 1kgx2 weights and PVC stick. - Cool down 5' and stretching.	- Progressive load training on an exercise bike (25 minutes; watts: 50-60); - Muscle strengthening with 2kgx2 weights and elastic band; - 5-minute cool-down and stretching.	- Aerobic training; - Strength training.

Table 1: Rehabilitation Protocol

Data analysis

For each sample of patients readmitted at 3 months, 4 months and 5 months, the mean and standard deviation for the STS1 and 6MWT values were calculated in order to determine the respective confidence intervals. A 95% confidence interval was chosen as it represent the scientific standard for optimally balancing the reliability of the estimate with precision, providing an acceptable margin of uncertainty for the effect observed in our sample of 18 patients. For each, the left and right extremes of the interval were calculated as shown in Tables 3-4-5. The value of the extremes took into account the normal approximation error of the confidence interval, which for our sample is equal to 0.2357. Finally, to evaluate the effectiveness of treatment with readmission at 3 months, 4 months and 5 months, we considered the average between the test values at the end of the first cycle and the beginning of the second. We used the Wilcoxon-Mann-Whitney hypothesis test (21), to compare the averages loss of treatment efficacy over the respective pause periods (readmission at 3, 4 or 5 months). It is a nonparametric test that does not require in advance selection of the data distribution law typically used to measure treatment efficacy.

Igiene e Sanità Pubblica 2025; 98 (5)

3. Results

The characteristics of the sample are shown in Table 2.

Follow up	**3 months**	**4 months**	**5 months**
Females n° (%)	10 (66.7)	5 (33.3)	5 (33.3)
Average age ± SD	70.4 ± 9.55	70.8 ± 9.3	65.7 ± 9.07
STST (T0)	9.83 ± 2.28	10.3 ± 2.9	9.05 ± 3.31
6MWT (T0)	335.8 ± 120.1	382.3 ± 116.9	330.77 ± 125.8
BORG pre-test (T0)	2.44 ± 3.23	1.38 ± 2.0	0.61 ± 1.03
BORG post-test (T0)	5.72 ± 5.05	4.38 ± 3.16	3.3 ± 1.97

Table 2: Characteristics of the sample examined

Se Tables 3-5 for the achieved results.

Third Month			
STS1 average on first access	9,83	STS1 average on first discharge	12,66
STS1 average on second access	10,77	STS1 avarage on second discharge	12,61
Average 6MWT first access	335,83	Avarage 6MWT first discharge	438,77
Average 6MWT second access	362,66	Avarage 6MWT second discharge	404,94
STS1 standard deviation on first access	2,28	STS1 standard deviation on first discharge	2,76
STS1 standard deviation on second access	2,31	STS1 standard deviation on second discharge	2,72
Standard deviation 6MWT first access	120,10	Standard deviation 6MWT first discharge	108,81
Standard deviation 6MWT second access	97,57	Standard 6MWT second discharge	106,87

Table 3: Characteristics of the sample readmitted at 3 months

Igiene e Sanità Pubblica 2025; 98 (5)

Fourth Month			
STS1 average on first access	10,33	STS1 average on first discharge	12,38
STS1 average on second access	10,77	STS1 avarage on second discharge	12,83
Average 6MWT first access	382,22	Average 6MWT first discharge	468,05
Average 6MWT second access	386,88	Average 6MWT second discharge	424,77
STS1 standard deviation on first access	2,93	STS1standard deviation first discharge	2,93
STS1 standard deviation on second access	2,83	STS1 standard deviation second discharge	3,18
Standard deviation 6MWT first access	116,95	Standard deviation 6MWT first discharge	112,97
Standard deviation 6MWT second access	78,70	Standard 6MWT second discharge	84,16

Table 4: Characteristics of the sample readmitted at 4 months

Fifth Month			
STS1 average on first access	9,05	STS1 average on first discharge	12,16
STS1 average on second access	9,83	STS1 avarage on second discharge	11,94
Average 6MWT first access	330,77	Average 6MWT first discharge	435,55
Average 6MWT second access	360,11	Avarage 6MWT second discharge	407,72
STS1 standard deviation on first access	3,31	STS1standard deviation first discharge	2,97
STS1 standard deviation on second access	2,33	STS1 standard deviation second discharge	2,66
Standard deviation 6MWT first access	125,88	Standard deviation 6MWT first discharge	87,27
Standard deviation 6MWT second access	106,01	Standard deviation 6MWT second discharge	111,59

Table 5: Characteristics of the sample readmitted at 5 months

Igiene e Sanità Pubblica 2025; 98 (5)

Confidence intervals: Tables 6-11 show the confidence intervals for the mean input and output, respectively, for the 3-, 4- and 5-month readmission periods relating to STS1 and 6MTW.

Left extreme STS1 first access	8,77	Right extreme STS1 first access	10,88
Left extreme STS1 second access	9,70	Right extreme STS1 second access	11,84
Left extreme 6MTW first access	280,34	Right extreme 6MWT first access	391,32
Left extreme 6MTW second access	317,58	Right extreme 6MWT second access	407,74

Table 6: STS and 6MWT confidence interval at 3 months entry

Third Month			
Left extreme STS1 first discharge	11,38	Right extreme STS1 first discharge	13,94
Left extreme STS1 second discharge	11,35	Right extreme STS1 second discharge	13,87
Left extreme 6MTW first discharge	388,51	Right extreme 6MTW first discharge	489,04
Left extreme 6MTW second discharge	355,57	Right extreme 6MTW second discharge	454,31

Table 7: STS and 6MWT confidence interval at 3 months output

Fourth Month			
Left extreme STS1 first access	8,97	Right extreme STS1 first access	11,68
Left extreme STS1 second access	9,46	Right extreme STS1 second access	12,089
Left extreme 6MTW first access	328,19	Right extreme 6MWT first access	436,25
Left extreme 6MTW second access	350,53	Right extreme 6MWT second access	423,24

Table 8: STS and 6MWT confidence interval at 4 months entry

Igiene e Sanità Pubblica 2025; 98 (5)

Fourth Month			
Left extreme STS1 first discharge	11,033	Right extreme STS1 first discharge	13,74
Left extreme STS1 second discharge	11,36	Right extreme STS1 second discharge	14,30
Left extreme 6MTW first discharge	415,86	Right extreme 6MTW first discharge	520,24
Left extreme 6MTW second discharge	385,89	Right extreme 6MTW second discharge	463,65

Table 9: STS and 6MWT confidence interval at 4 months output

Fifth Month			
Left extreme STS1 first access	7,52	Right extreme STS1 first access	10,58
Left extreme STS1 second access	8,75	Right extreme STS1 second access	11,06
Left extreme 6MTW first access	272,62	Right extreme 6MWT first access	388,93
Left extreme 6MTW second access	311,13	Estremo destro 6MTW secondo accesso	409,08

Table 10: STS and 6MWT confidence interval at 5 months entry

Fifth Month			
Left extreme STS1 first discharge	10,79	Right extreme STS1 first discharge	13,54
Left extreme STS1 second discharge	10,71	Right extreme STS1 second discharge	13,17
Left extreme 6MTW first discharge	395,23	Right extreme 6MTW first discharge	475,87
Left extreme 6MTW second discharge	356,17	Right extreme 6MTW second discharge	459,27

Table 11: STS and 6MWT confidence interval at 5 months output

4. Discussion

It can be immediately verified that the confidence intervals for the 3-month group and the 4-month group show minimal differences, unlike the confidence intervals for the 5-month group. For each of the tests carried out both at entry and exit, it can be seen that the left and right extremes are lower than those of the other groups.

The Wilcoxon-Mann-Whitney hypothesis test shows that the treatment is more effective when carried out 3 or 4 months after the last treatment, compared to the sample with an entry at 5 months.

The study revealed the importance of initiating comprehensive and individualised pulmonary rehabilitation protocols to reduce the incidence of exacerbations, thus also producing economic and health benefits (13,14). Statistical analysis confirmed a shared approach to planning long-term readmissions, thus facilitating the management of waiting lists and the staff involved, improving the quality of the service in terms of efficiency and productivity.

5. Limitations of the study

The statistical limitations of the study are represented by the small sample size (n=18) and the short period of treatment cycles (comparison between 3 months, 4 months and 5 months). The former affects the construction of confidence intervals as it is not possible to take into account the approximation of the normal distribution. For the same reason, this affects the choice of the Wilcoxon hypothesis test. Furthermore, a larger sample would allow for a study of multiple classes, such as division by gender and age and their correlation with the results of the various tests.

6. Conclusions

At a time of great criticality for the SSR, the management organisation of the lists guarantees the constant pursuit of equity of access to care and accessibility to the service, understood as the ability of a service or environment to be usable without barriers for everyone and to reach the highest number of users with COPD. Telerehabilitation and telemonitoring could represent a great opportunity that can increase the level of enforceability of citizens' right to health, sustainability and innovation of the National Health System.

Bibliography

1. Haddad M, Sharma S. Physiology, Lung. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 [citato 19 giugno 2025]. Disponibile su: http://www.ncbi.nlm.nih.gov/books/NBK545177/
2. Cirio S, Clini EM, Gaudiello G, Gigliotti F, Vitacca M. Broncopneumopatia cronica ostruttiva (BPCO). Rassegna Patol DellApparato Respir. aprile 2022;37(Supplement 1 to issue 1_2022):S6–9.
3. Agustí A, Celli BR, Criner GJ, Halpin D, Anzueto A, Barnes P, et al. Global Initiative for Chronic Obstructive Lung Disease 2023 Report: GOLD Executive Summary. Eur Respir J. aprile 2023;61(4):2300239.
4. Nozzoli GEC, Gensini G, Fabbri LM. Broncopneumopatia cronica ostruttiva e comorbidità croniche. Ital J Med. 30 aprile 2013;S1–150.

5. Celli BR, Decramer M, Wedzicha JA, Wilson KC, Agustí A, Criner GJ, et al. An Official American Thoracic Society/European Respiratory Society Statement: Research Questions in Chronic Obstructive Pulmonary Disease. Am J Respir Crit Care Med. 1 aprile 2015;191(7):e4–27.
6. Rothnie KJ, Müllerová H, Smeeth L, Quint JK. Natural History of Chronic Obstructive Pulmonary Disease Exacerbations in a General Practice–based Population with Chronic Obstructive Pulmonary Disease. Am J Respir Crit Care Med. 15 agosto 2018;198(4):464–71.
7. Lu HY, Chen CF, Lee DL, Tsai YJ, Lin PC. Effects of Early Pulmonary Rehabilitation on Hospitalized Patients with Acute Exacerbation of Chronic Obstructive Pulmonary Disease: A Systematic Review and Meta-Analysis. Int J Chron Obstruct Pulmon Dis. maggio 2023;Volume 18:881–93.
8. Rosenberg S, Kalhan R, Mannino D. Epidemiology of Chronic Obstructive Pulmonary Disease: Prevalence, Morbidity, Mortality, and Risk Factors. Semin Respir Crit Care Med. 3 agosto 2015;36(04):457–69.
9. Wedzicha JA, Miravitlles M, Hurst JR, Calverley PMA, Albert RK, Anzueto A, et al. Management of COPD exacerbations: a European Respiratory Society/American Thoracic Society guideline. Eur Respir J. marzo 2017;49(3):1600791.
10. Silva BSA, Ramos D, Bertolini GN, Freire APCF, Leite MR, Camillo CA, et al. Resistance exercise training improves mucociliary clearance in subjects with COPD: A randomized clinical trial. Pulmonology. 30 novembre 2019;25(6):340–7.
11. Wada J, Borges-Santos E, Porras D, Paisani D, Cukier A, Lunardi A, et al. Effects of aerobic training combined with respiratory muscle stretching on the functional exercise capacity and thoracoabdominal kinematics in patients with COPD: a randomized and controlled trial. Int J Chron Obstruct Pulmon Dis. ottobre 2016;Volume 11:2691–700.
12. Nyberg A, Martin M, Saey D, Milad N, Patoine D, Morissette MC, et al. Effects of Low-Load/High-Repetition Resistance Training on Exercise Capacity, Health Status, and Limb Muscle Adaptation in Patients With Severe COPD. Chest. maggio 2021;159(5):1821–32.
13. Zambom-Ferraresi F, Cebollero P, Gorostiaga EM, Hernández M, Hueto J, Cascante J, et al. Effects of Combined Resistance and Endurance Training Versus Resistance Training Alone on Strength, Exercise Capacity, and Quality of Life in Patients With COPD. J Cardiopulm Rehabil Prev. novembre 2015;35(6):446–53.
14. He GX, Li N, Ren L, Shen HH, Liao N, Wen JJ, et al. Benefits of different intensities of pulmonary rehabilitation for patients with moderate-to-severe COPD according to the GOLD stage: a prospective, multicenter, single-blinded, randomized, controlled trial. Int J Chron Obstruct Pulmon Dis. ottobre 2019;Volume 14:2291–304.
15. Casati G, Panella M, Di Stanislao F. Gestione per processi professionali e percorsi assistenziali. Terza. Vol. 1. Roma-Ancona; 2005.
16. Galeoto G, Mollica R, Astorino O, Cecchi R. [Informed consent in physiotherapy: proposal of a form]. G Ital Med Lav Ergon. 2015;37(4):245–54.
17. Bohannon RW, Crouch R. 1-Minute Sit-to-Stand Test: SYSTEMATIC REVIEW OF PROCEDURES, PERFORMANCE, AND CLINIMETRIC PROPERTIES. J Cardiopulm Rehabil Prev. gennaio 2019;39(1):2–8.

18. ATS Statement: Guidelines for the Six-Minute Walk Test. Am J Respir Crit Care Med. 1 luglio 2002;166(1):111–7.
19. Enright PL. The six-minute walk test. Respir Care. agosto 2003;48(8):783–5.
20. Penko AL, Barkley JE, Koop MM, Alberts JL. Borg scale is valid for ratings of perceived exertion for individuals with Parkinson's disease. Int J Exerc Sci. 2017;10(1):76–86.
21. Hollander, M., Wolfe, D. A., & Chicken, E. (2013). Nonparametric Statistical Methods (3rd ed.). Wiley.

Corresponding author:
Matteo Tamburlani
Phone number: 3382243173
Address: Via Portella 49 – 00049 – Velletri (RM)
E-mail: matteo.tamburlani@aslroma2.it