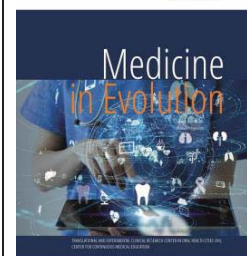


The impact of a rehabilitation program on static, locomotion, and balance impairments in COPD patients



Carunta V.¹, Almajan B.^{2*}, Crisan A.F.³, Pescaru C.C.⁴, Galuscan A.⁵, Jumanca D.E.⁵

¹Faculty of Physical Education and Sports, West University of Timisoara, Vasile Paroan Street 4, 300223 Timisoara, Romania

²Department of Physical Therapy and Special Motor Skills, Faculty of Physical Education and Sport, West University of Timisoara, Vasile Paroan Street 4, 300223, Timisoara, Romania

³Department of Balneology, Medical Rehabilitation and Rheumatology, University of Medicine and Pharmacy "Victor Babes" Timisoara, Romania

⁴Department of Pneumology, University of Medicine and Pharmacy "Victor Babes", Timisoara

⁵1st Department of Dentistry, Faculty of Dental Medicine, University of Medicine and Pharmacy Victor Babes" Timisoara, Romania

Correspondence to:

Name: Almajan-Guta Bogdan

Address: Vasile Paroan Boulevard 4, Timisoara 300223

Phone: +40 722723537

E-mail address: bogdan.almajan@e-wot.ro

Received: 4 May 2024; Accepted: 18 June 2024; Published: 30 June 2024

Abstract

Aim and Objectives: Investigating balance impairments and developing a structured rehabilitation plan can significantly improve the safety and reduce the risk of falls in COPD patients.

Material and methods: The study included ten patients with severe to very severe COPD who comprised the intervention group, and ten mild COPD patients who comprised the control group, with similar demographic data. Tests were used to assess balance and gait.

Results: The intervention group was associated with worse outcomes in the initial evaluation of the balance tests, consisting of SLS, TUG, and 6MWT. However, at the end of the rehabilitation program, the intervention group registered an increase in SLS time and 6MWT distance and a decrease in TUG test time.

Conclusions: Following a 3-week rehabilitation program, patients with severe to very severe COPD decreased the risk of falls and showed a higher independence rate.

Keywords: COPD, balance impairment, abnormal gait, rehabilitation

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a progressively worsening and life-threatening condition that affects an estimated 251 million people worldwide, including more than 15 million people in the United States [1]. It ranks as the third leading cause of death in the US, contributing significantly to impaired mobility, disability, and reduced quality of life. People with COPD often experience decreased strength, endurance, and balance, along with changes in gait, all of which further diminish their quality of life [1].

In addition to these physical impairments, a significant percentage (57.6%) of people with COPD also live with considerable cognitive deficits. The presence of COPD is linked to a high risk of cognitive decline over time, even among adults with mild COPD [1].

Impairments in cognitive function are related to changes in gait quality, reduced balance, and increased incidence of falls and injuries. In people with cognitive impairment, there is a significant association between impaired cognitive function and reduced or slowed walking speed [2].

Aim and objectives

While the impact of COPD on lung function is well established, the interaction between statics, locomotion, and balance is still poorly studied. Further research may reveal how these factors influence each other, leading to a more comprehensive approach to patient management.

Current COPD management focuses mainly on respiratory symptoms. However, tackling static, locomotion, and balance problems require specific interventions. Research can pave the way for personalized training programs, assistive devices, and rehabilitation strategies tailored to individual patient needs and limitations.

Falls are a major concern for COPD patients, often leading to serious injury and reduced quality of life. Investigating balance deficiencies and developing a structured rehabilitation plan can improve safety and postural control. Early detection of problems with statics, locomotion, and balance can allow prompt intervention before functional limitations become severe.

Research into static, locomotion, and balance impairments in COPD patients has immense potential to improve their balance, reduce healthcare costs, and advance scientific and clinical understanding of the disease.

MATERIALS AND METHODS

The study included ten patients with severe to very severe COPD, who constituted the intervention group, and 10 patients with mild COPD, who constituted the control group. Both patients and control subjects were recruited from the “Doctor Victor Babeş” Clinical Hospital for Infectious Diseases and Pneumophthysiology Timisoara to participate in this study.

Criteria for inclusion of patients with COPD consisted of a primary diagnosis of COPD from severe to very severe, according to the norms and criteria defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD), which require inclusion of patients with a Peak Expiratory Volume per Second (FEV1) rate between 30-50% for severe COPD and below 30% for very severe COPD, reliance on non-invasive ventilation, cessation of tobacco use, and ability to remain unassisted in orthostatic and walking conditions.

Subjects in the control group consisted of patients with mild COPD with an FEV1 rate of 80% or above and were able to sustain body weight in orthostatic and walking conditions.

Patients in the intervention group followed a three-week, individualized rehabilitation program focused on muscle strengthening and improved respiratory function, coordination, balance, proprioception, and gait.

The rehabilitation program was conducted by a team of physiotherapists specialized in pulmonary rehabilitation, with a frequency of 2 training sessions per day, five days per week, for three weeks. For the physical training to be effective, the total training load surpassed the demands encountered in daily life to improve aerobic capacity and muscular strength, progressing as they improve.

The rehabilitation program included resistance training, which aimed to condition the muscles responsible for locomotion and increase cardiorespiratory capacity to allow an increase in physical activity, simultaneously with an improvement in dyspnoea and fatigue, with an intensity of 60% of maximum work rate, a duration of between 10 to 20 minutes initially, gradually increasing to 25-30 minutes, a frequency of 5 sessions per week and a limit of perceived exertion of 4 to 6 on the modified Borg scale.

Interval training has also been included in the rehabilitation program, with the advantage of performing repeated bouts of higher intensity exercise, but over a shorter period of time than resistance training, with an intensity of 70% of the maximum work rate, gradually added up to 90-100%, exercise intensity of 30 seconds with 30 seconds pause, or 20 seconds with 40 seconds of rest, depending on the patient's characteristics for a total of 10 minutes, gradually increased to 15-20 minutes for a total of 5 sessions per week.

The final component of the rehabilitation program consisted of strength training, also recommended by the American College of Sports Medicine, for increasing muscle strength in adults. It consisted of 1-2 sets with 8 to 12 repetitions at a frequency of 5 sessions per week, with an initial load of 60%-70% of individual maximal repetition potential gradually increased to 100% [3].

The BTS P-Walk sensory platform was used on the intervention and control groups to identify balance and gait disturbances and help prepare the rehabilitation plan. The BTS P-Walk facilitates assessing plantar pressure and force distribution in both static and dynamic stages, providing quantitative information about plantar support to identify plantar overloads, rotations, and postural asymmetries. This type of analysis allows for assessing the patient's level of balance by identifying the COG (center of gravity) position and quantifying the postural sway of the patient in an orthostatic position.

Patients performed both on the first day of training and at the end of the rehabilitation program a series of tests to assess aerobic capacity, static balance, and general mobility. The tests used were the 6-minute walk test (6MWT), Single-Leg Stance (SLS), and Timed Up-and-Go (TUG).

RESULTS

The analysis of data and statistical results was carried out using IBM SPSS Statistics software, which evaluated the results of the intervention group both at the beginning and at the end of the rehabilitation program, as opposed to the control group, which was only evaluated initially, as they did not undergo an intervention program.

Following the initial test of the distribution of stepping time and plantar area using the BTS P-Walk plate, the differences recorded between the groups were expressed in Table I:

Table 1. Results of initial testing of foot pressures and forces

Test	Intervention	Control
Left lower limb stepping time	1770,8 ms	1072,8 ms
Right lower limb stepping time	1438 ms	1086,7 ms

Difference in stepping time	327,8 ms	88,2 ms
Area covered by the left lower limb	233,9 cm ²	155,8 cm ²
Area covered by the right lower limb	188,7 cm ²	170,6 cm ²
Difference in area covered	48,2 cm ²	17,3 cm ²

Following the evaluation, the statistical differences of the recorded measurements in the Independent Sample T-test, were:

- Difference in left lower limb stepping time between groups*
- p=0.001
 - Right lower limb stepping time*
- p= 0.05
 - Difference in stepping time*
- p= 0,01

 - Area covered by the left lower limb*
- p= 0,02
 - Area covered by the right lower limb
- p= 0,43
 - Difference in area covered*
- p= 0,05
- *Statistically significant difference = $p < 0.05$

In the initial assessment of the SLS test, the intervention group had lower values of time spent maintaining an orthostatic position on the dominant lower limb (16.5 seconds) compared to the control group (55.2 seconds). The statistical difference was $p=0.01$, thus demonstrating a statistically significant difference between the two groups.

In the initial assessment of the TUG test, the intervention group had higher values of execution times (higher times correlated with greater difficulty in maintaining balance) compared to the control group (19 seconds vs. 8.9 seconds). The statistical difference being $p = 0.003$, thus demonstrating a statistically significant difference between the two groups.

Also, in the initial assessment, the intervention group showed lower values of the distance covered in the 6MWT, expressed in meters (m), as well as the final percentage, with an average of 247 m and 58%, compared to the control group, which recorded an average of 440 m and 92%, the statistical difference being $p = 0.01$ and $p = 0.03$ in the percentage difference, respectively, demonstrating the existence of a statistically significant difference between the two groups.

At the end of the rehabilitation program, the intervention group repeated the tests to identify the program's impact on static and dynamic balance and aerobic capacity. Thus, compared to the baseline, the intervention group showed an increase in the time to maintain balance on the dominant lower limb in the SLS test, with an average of 22.7 seconds compared to the baseline of 16.5 seconds. The statistical difference between baseline and end-stage was $p = 0.02$.

At the second evaluation of the TUG test, the intervention group had lower execution time values, with an average of 15.4 seconds, compared to the initial 19 seconds. The statistical difference recorded $p= 0.001$ demonstrates a statistically significant difference between the two stages.

At the end of the rehabilitation program, the intervention group had a higher mean distance and percentage covered in the 6MWT, with an average of 284 m and 68%, compared to 247 m and 58% in the initial evaluation. The statistical difference was $p = 0.03$ and 0.02 in

percentage difference, respectively, demonstrating a statistically significant difference between the two evaluations.

DISCUSSIONS

The study aimed to demonstrate that people with severe to very severe COPD have impairments in both balance and gait compared to mild COPD patients. Furthermore, the objective was to demonstrate that a structured rehabilitation program significantly improves balance and gait among patients with severe to very severe COPD compared to those without such an intervention. Results suggest that interventions focused on skeletal and respiratory muscle groups offer potential benefits in postural control and dynamic balance, thus mitigating the risk of falls for people with COPD.

Initially, significant differences were observed in the TUG and SLS tests, with the intervention group showing a longer completion time for the TUG test and a shorter time for the SLS compared to the control group.

However, following the 3-week rehabilitation program, the intervention group demonstrated a decrease in TUG test completion time and an improvement in SLS test completion time. These results are consistent with previous investigations by other authors [4,5].

Beauchamp et al. identified an increase in lower limb musculature and gait speed, associating these results with improvement in TUG test scores within the same group before and after a rehabilitation program [4].

Similarly, Marques et al. observed a reduction in TUG completion time following a rehabilitation program in the intervention group, noting increased gait speed and improved proprioceptive coordination [5].

The SLS test results are also consistent with Mkacher et al. who recorded a significant difference in test completion time following an extended rehabilitation program, which correlated with a decreased risk of destabilization and falls [6].

Our results are in line with the findings of Kerti et al., who identified an increase in aerobic capacity in terms of distance covered in the 6-minute walk test between their intervention group (undergoing pulmonary rehabilitation and inspiratory muscle training) and the control group (undergoing pulmonary rehabilitation only) after a 4-week rehabilitation program.

Patients in the intervention group initially had a longer mean walking time (1604ms vs. 1079ms) and a larger base of support (211cm² vs. 163cm²) compared to those in the control group, indicating a less flexible and adaptive movement pattern, factors often associated with a higher risk of falling.

The prolonged step time and increased size of the base of support observed among the severe to very severe COPD patients in this study suggests a possible mechanism that could explain, at least in part, why this population has a higher risk of falls.

The study had some limitations. Firstly, a restricted time frame for accessing and using the BTS P-Walk plates prevented us from evaluating plantar distributions after the rehabilitation program. Secondly, the rehabilitation program was conducted over only three weeks. It included a relatively small sample size, thus requiring further analysis to determine the lasting impact of muscle and balance training on patients with COPD. Finally, the inclusion criteria exclusively targeted COPD patients with severe to very severe airflow limitation, which constrained the overall generalizability of our findings. Further studies involving larger cohorts of COPD patients are warranted to validate these results.

CONCLUSIONS

Our results indicate that following a 3-week rehabilitation program incorporating aerobic, strength, and balance exercises effectively improves balance control in static and dynamic movements in patients with severe to very severe COPD, with a reduced risk of falls.

REFERENCES

1. Gore S, Blackwood J, Ziccardi T. Associations between Cognitive Function, Balance, and Gait Speed in Community-Dwelling Older Adults with COPD. *Journal of Geriatric Physical Therapy*. 2023 Jan 1;46(1):46-52.
2. Loughran KJ, Atkinson G, Beauchamp MK, Dixon J, Martin D, Rahim S, et al. Balance impairment in individuals with COPD: a systematic review with meta-analysis. *Thorax*. 2020 May 14;75(7):539-46.
3. Nolan CM, Rochester CL. Exercise Training Modalities for People with Chronic Obstructive Pulmonary Disease. Vol. 16, COPD: *Journal of Chronic Obstructive Pulmonary Disease*. Taylor and Francis Ltd; 2019. p. 378-89.
4. Beauchamp MK, Hao Q, Kuspinar A, D'Amore C, Scime G, Ma J, et al. Reliability and minimal detectable change values for performance-based measures of physical functioning in the canadian longitudinal study on aging. *Journals of Gerontology - Series A Biological Sciences and Medical Sciences*. 2021 Nov 1;76(11):2030-8.
5. Marques A, Jácome C, Cruz J, Gabriel R, Figueiredo D. Effects of a Pulmonary Rehabilitation Program with Balance Training on Patients with COPD. *J Cardiopulm Rehabil Prev*. 2015 Dec 1;35(2):154-8.
6. Mkacher W, Mekki M, Tabka Z, Trabelsi Y. Effect of 6 Months of Balance Training during Pulmonary Rehabilitation in Patients with COPD. *J Cardiopulm Rehabil Prev*. 2015 Dec 1;35(3):207-13.