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Adherence to Pulmonary Rehabilitation in Patients with Chronic Obstructive Pulmonary Disease (COPD)

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Abstract: Background: Pulmonary rehabilitation (PR) allows for the treatment of patients with chronic obstructive pulmonary disease (COPD) as an intervention strategy that improves functional capacity, dyspnea, and health-related quality of life. However, adherence to such programs might be improved. This study aimed to describe the differences in sociodemographic and clinical variables, functional capacity, and health-related quality of life in patients diagnosed with COPD adherent and non-adherent to pulmonary rehabilitation at a clinic in Cali, Colombia. Methods: This study followed a descriptive cross-sectional model with 150 patients diagnosed with COPD. Adherence was classified by taking into account the number of sessions completed: low (<35%), moderate (35–85%), and high (>85%). Sociodemographic, clinical, functional capacity, and health-related quality of life variables were considered. Results: Adherence to the PR was rated as high in 57.3% of patients. Variables such as sex, health system affiliation, height, functional capacity, resting SaO_2, and health-related quality of life presented significant differences (p-value ≤ 0.05). The main causes of non-adherence to the program were medical recommendations that prevented continuing in the program due to clinical and safety issues and economic issues that prevented reaching the rehabilitation site, as it was unaffordable. Conclusions: It can be concluded that adherence to pulmonary rehabilitation was rated as high in 57.3% of patients. The high adherence to the PR program occurred in male patients with a capacity to pay the Colombian health system (contributory regime).

Keywords: adherence; pulmonary rehabilitation; disease; COPD

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1. Introduction

Non-communicable diseases (NCDs) are the cause of a high mortality rate according to the World Health Organization (WHO); those are equivalent to 71% of deaths worldwide [1]. Chronic respiratory diseases are within this group, of which chronic obstructive pulmonary disease (COPD) is the most frequent. Patients with this disease present a persistent airflow reduction and symptoms, such as chronic cough, expectoration, dyspnea, and exacerbations [2].

COPD is a leading cause of increased morbidity and mortality. It is predicted to be the third leading cause of death worldwide. The number of COPD cases was estimated to be 384 million in 2010 with a global prevalence of 11.7%. There are about 3 million deaths per year worldwide [3]. The Colombian Pneumological Foundation determined that 9 out of every 100 people over 40 had COPD; 8.5% corresponds to the cases in Cali, Colombia [2,3].

Pharmacological and non-pharmacological treatments are recommended for patients suffering from the disease. In the case of patients with non-pharmacological treatment, PR

is effective in improving exertional dyspnea, exercise capacity, and health-related quality of life [4].

Regarding adherence to PR, a measurement based on the compliance model has been proposed, and it is considered to be completed based on the number of sessions attended or prescribed, which correspond to low (<35%), moderate (35–85%), and high (>85%) [5]. Some evidence shows that certain sociodemographic conditions may have the same or a more significant relationship with adherence to these programs. However, it is necessary to investigate these relationships in different contexts [5].

There is little evidence of adherence to PR programs. Therefore, this study aimed to describe the differences in sociodemographic and clinical variables, functional capacity, and health-related quality of life in patients who had a diagnosis of COPD confirmed by a pulmonologist and entered a PR program at a clinic in Cali, Colombia.

2. Materials and Methods

This investigation followed a descriptive cross-sectional model using information from primary sources, including patients who had a diagnosis of COPD confirmed by a pulmonologist and entered a PR program at a clinic in Cali.

The population included 150 patients diagnosed with COPD and referred to a PR program from August 2020 to April 2021. This study adopted the resolution No. 8430 of 4 October 1993 of the Ministry of Health and Social Protection of Colombia, establishing the scientific and administrative standards for health research, the Declaration of Helsinki. The study had the approval of the ethics committee through code # 126.01.05.02. Before patient enrollment, the study was explained in detail, and questions were resolved to sign the informed consent if the following inclusion criteria were met.

Main inclusion criteria were age between 45 and 85 years; diagnosis of COPD confirmed by a pneumologist according to GOLD guidelines (ref), confirmed by post-bronchodilator FEV1/FVC ratio < 0.7; signed informed consent; and first time in a PR program. Exclusion criteria were mental or cognitive alterations likely to prevent understanding and following instructions, physical limitations that prevented performing the 6MWT, and uncontrolled cardiac and metabolic diseases. Considering total adherence as completion of 24 sessions (standard of care in Colombia), participants were assigned to three groups: low adherent < 35%, moderate adherent between 36 and 85%, and high adherent > 85% [5].

The variables considered were sex; age; marital status; place of residence; stratum; health regime, which comprises two categories, (1) the subsidized regime, which covers the population with no ability to pay, and (2) the contributory regime, which covers the population that pays into the health system; emergency room visits for respiratory complications; hospitalizations in the last year for respiratory complications; days hospitalized; exposure to wood smoke; time of exposure to wood smoke; current smoking; Pack/Year (P/Y) index; home oxygen; weight; height; Body Mass Index (BMI); dyspnea Medical Research Council Modified (mMRC); spirometry in predicted values FEV1, FVC, FEV1/FVC; days in the program; number of sessions; adherence rating; distance traveled in the 6MWT; predicted distance (Enright) 6MWT; Heart Rate (HR) (resting, end, one minute after end, five minutes after end) during the 6MWT; Heart rate recovery (HRR); peripheral oxygen saturation (SpO2) (rest, end, one minute after end, 5 min after end) during the 6MWT; desaturation percentage; respiration rate (RR) (rest, end, one minute after end, five minutes after end) during the 6MWT; stops made in the 6MWT; VO2e; MET; health-related quality of life with the Saint George's Respiratory Questionnaire (SGRQ); Chronic Respiratory Disease Questionnaire SAS (CRQ-SAS) and the Hospital Anxiety and Depression Scale (HADS); and the reasons for leaving the program.

2.1. Procedures

This study used primary and secondary sources of information. Regarding the primary sources, during the initial visit, a physiotherapist specialized in PR explained to the patient the purpose of the study. Subsequently, admission questionnaires, such as SGRQ

and CRQ-SAS, related to sociodemographic conditions and health-related quality of life; the anxiety and depression questionnaire (HADS) and mMRC scale were applied. An anthropometric, spirometry, and functional capacity (6WMT) evaluation was performed during the second visit.

Secondary sources of information were obtained from the patient's clinical history through the Individual Health Service Provision Records (RIPS by its initials in Spanish) and referral by a specialist physician (pulmonologist). Hospitalizations in the last year, emergency room visits, home oxygen use, and GOLD classification were obtained from the medical records as well.

Patients underwent an initial evaluation for admission to the PR program for eight weeks, attending three times a week with an estimated duration of 60 min and 24 sessions in which an attendance record was filled out. In the PR program, the patient was evaluated to verify if they completed the established sessions based on the attendance record, reporting the number of sessions attended, and classifying adherence as low, moderate, or high according to session compliance. In case of drop-out, the reasons were recorded with telephone calls.

Each session comprised continuous exercise on a treadmill or ergometric bicycle for 30 min, starting at 60% of the max workload reached in the TC6M; the progression in exercise intensity was carried out using the modified Borg scale, always increasing until a score between 3 (moderate) and 5 (severe), which was maintained. Muscle strengthening exercises were also implemented (4 sets of 12 repetitions) starting at 50% of maximum resistance (RM) and increasing until a score between 3 (moderate) and 5 (severe), which was maintained. The educational component included individual and group sessions related to knowledge of the disease, the importance of smoking cessation, the use of inhaler's devices and proper technique of inhalation, recognition of warning signs, use of home oxygen, proper nutrition, measures against panic and anxiety, and home breathing exercises.

2.2. Statistical Analysis

A database was created in Excel 2010 to analyze the information. The results were processed in the SPSS 24 statistical package. Descriptive statistics were used to present the main characteristics of the patient at the time of admission to the PR program. Qualitative variables are presented in frequencies and percentages. The Kolmogorov–Smirnov test was applied for parametric variables, as mean and standard deviation. Finally, the Chi2 test was used to compare the groups with high adherence and low/moderate adherence to the PR program in the qualitative variables. The one-way ANOVA test was used for quantitative variables; subsequently, post hoc tests were performed. Tukey's test was used for parametric variables, which presented equality of variances (adjusting for unbalanced groups with Dunnett's T3 test). When equality of variances was not assumed, Dunnett's T3 test was used. A p-value < 0.05 was considered statistically significant, taking into account a significance of 95%.

3. Results

Out of 282 patients admitted at the PR, 180 had a confirmed diagnosis of COPD according to the inclusion criteria, and 30 patients were excluded: 15 did not meet the inclusion criteria, and the remaining 15 were excluded because they did not have complete information at the time of data entry. Finally, 150 patients diagnosed with COPD who fulfilled all the admission and data entry criteria were analyzed (Figure 1).

Adherence was rated as low, moderate, or high in 13 (48.1%), 16 (40.0%), and 56 (67.5%) patients, respectively (p-value = 0.010). When considering the health regimen, the majority belonged to the contributory regimen, 119 (79.3%). It was found that 17 (63%), 10 (27%), 36 (90%) and 4 (10%), 66 (79.5%), and 17 (20.5%) were the patients assessed with low, moderate, and high adherence in the subsidized and contributory regimen, respectively (p = 0.027) (Table 1).

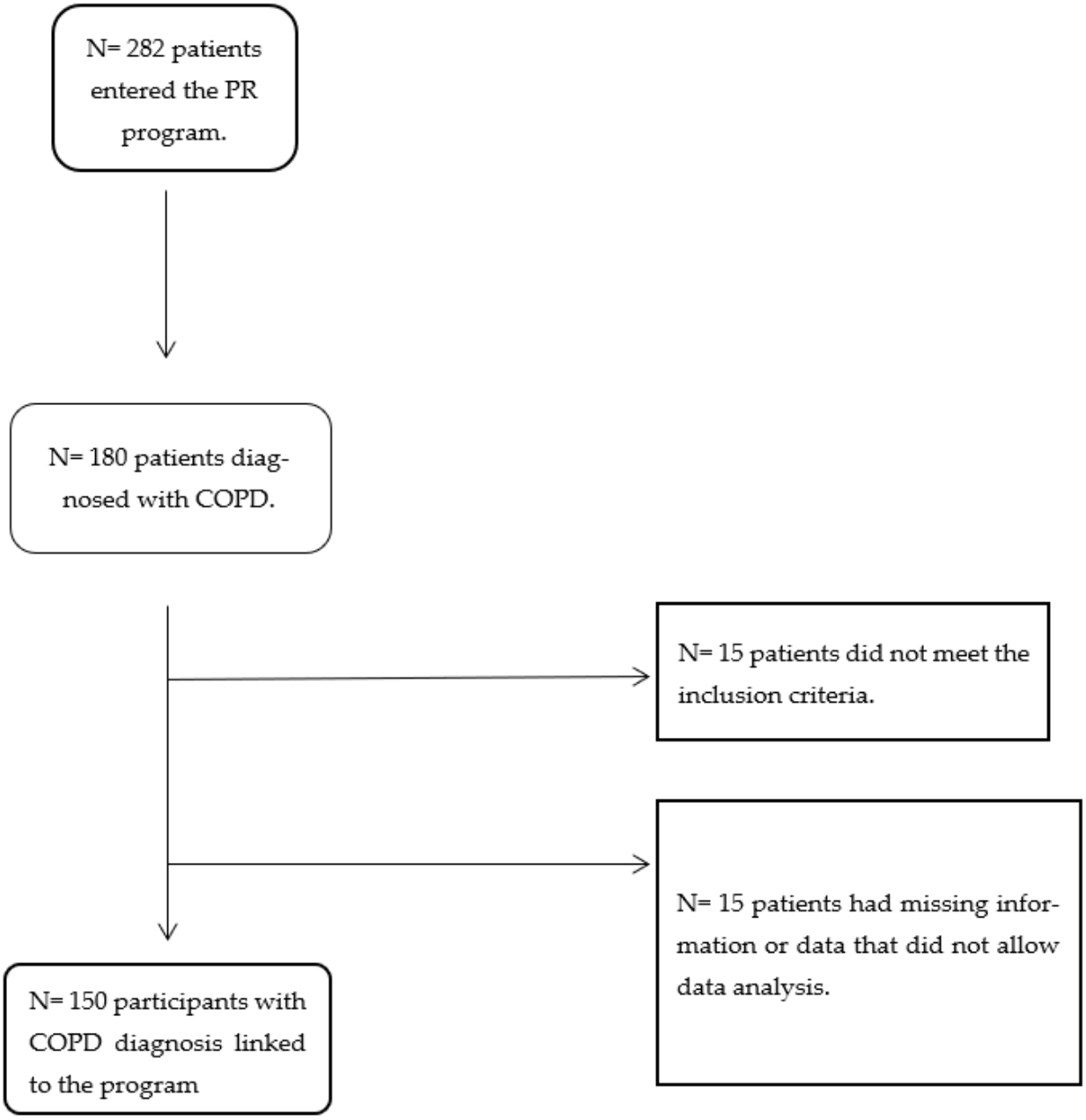

Figure 1. Admission of COPD patients to the PR program.

Table 1. Sociodemographic differences among patients with COPD.

Variables	Total n = 150	Low Adherence n = 27	Moderate Adherence n = 40	High Adherence n = 83	*p*-Value
Sex					
Male	85 (56.7%)	13 (48.1%)	16 (40.0%)	56 (67.5%)	0.010
Female	65 (43.3%)	14 (51.9%)	24 (60.0%)	27 (32.5%)	
Age	70.96 ± 9.58 *	70.4 ± 8.84 *	70.6 ± 10.19 *	71.2 ± 9.61 *	0.893
Coexistence					
Lives with a partner	86 (57.3%)	14 (51.9%)	23 (57.5%)	49 (59.0%)	0.806
Lives alone	64 (42.7%)	13 (48.1%)	17 (42.5%)	34 (41.0%)	
Place of Residence					

Table 1. *Cont.*

Variables	Total n = 150	Low Adherence n = 27	Moderate Adherence n = 40	High Adherence n = 83	*p*-Value
Cali	130 (86.7%)	22 (81.5%)	32 (80.0%)	76 (91.6%)	
Outside Cali in the department	17 (11.3%)	3 (11.1%)	7 (17.5%)	7 (8.4%)	0.087
Other department Stratum	3 (2.0%)	2 (7.4%)	1 (2.5%)	-	
Low	75 (50.0%)	15 (55.6%)	21 (52.5%)	39 (47.0%)	0.913
Middle	62 (41.3%)	10 (37.0%)	15 (37.5%)	37 (44.6%)	
High	13 (8.7%)	2 (7.4%)	4 (10.0%)	7 (8.4%)	
Health Regime					
Subsidized	31 (20.7%)	10 (37.0%)	4 (10.0%)	17 (20.5%)	0.027
Contributory	119 (79.3%)	17 (63.0%)	36 (90.0%)	66 (79.5%)	

* Values expressed as mean and standard deviation.

In the clinical variables, a total average was obtained for height 1.60 ± 0.091 having low adherence, 1.58 ± 0.07; moderate adherence, 1.57 ± 0.098; and high adherence, 1.61 ± 0.089 (*p*-value = 0.024) (Table 2).

Table 2. Clinical differences among patients with COPD.

Variables	Total n = 150	Low Adherence n = 27	Moderate Adherence n = 40	High Adherence n = 83	*p*-Value
Emergency room visits	1.60 ± 2.557	1.11 ± 1.67	2.00 ± 2.602	1.57 ± 2.75	0.374
Yes	99 (66.0%)	15 (55.6%)	26 (65.0%)	58 (69.9%)	0.389
No	51 (34.0%)	12 (44.4%)	14 (35.0%)	25 (30.1%)	
Hospitalization Last year	0.81 ± 1.184	0.52 ± 0.64	0.90 ± 1.317	0.87 ± 1.24	0.359
Yes	79 (52.7%)	12 (44.4%)	21 (52.5%)	46 (55.4%)	0.611
No	71 (47.3%)	15 (55.6%)	19 (47.5%)	37 (44.6%)	
Days hospitalized	8.39 ± 12.67	4.30 ± 5.77	10.9 ± 16.18	8.51 ± 12.1	0.111
Exposure to wood smoke					
Yes	45 (30.0%)	11 (40.7%)	13 (32.5%)	21 (25.3%)	0.290
No	105 (70.0%)	16 (59.3%)	27 (67.5%)	62 (74.7%)	
Wood smoke (years)	4.87 ± 9.484	6.81 ± 10.76	6.45 ± 11.28	3.48 ± 7.85	0.134
Smoked					
Yes	125 (83.3%)	25 (92.6%)	31 (77.5%)	69 (83.1%)	0.266
No	25 (16.7%)	2 (7.4%)	9 (22.5%)	14 (16.9%)	
Smoke Currently					
Yes	8 (5.3%)	3 (11.1%)	1 (2.5%)	4 (4.8%)	0.292
No	142 (94.7%)	24 (88.9%)	39 (97.5%)	79 (95.2%)	
P/A Ratio	27.1 ± 28.33	26.3 ± 26.32	29.7 ± 32.26	26.2 ± 27.18	0.800
Home Oxygen					
Yes	73 (48.7%)	12 (44.4%)	23 (57.5%)	38 (45.8%)	0.424
No	77 (51.3%)	15 (55.6%)	17 (42.5%)	45 (54.2%)	
Weight (Kg)	64.8 ± 13.96	66.2 ± 15.1	63.3 ± 13.96	65.1 ± 13.67	0.689
Height (Mts) **	1.60 ± 0.091	1.58 ± 0.07 **	1.57 ± 0.098 **	1.61 ± 0.089 **	0.024
BMI (Kg/mts^2)	25.3 ± 5.219	26.3 ± 5.36	25.5 ± 5.435	24.8 ± 5.06	0.396
BMI Classification					
Thin	12 (8.0%)	-	5 (12.5%)	7 (8.4%)	0.051
Normal	62 (41.3%)	13 (48.1%)	11 (27.5%)	38 (45.8%)	
Overweight	51 (34.0%)	6 (22.2%)	19 (47.5%)	26 (31.3%)	

Table 2. *Cont.*

Variables	Total n = 150	Low Adherence n = 27	Moderate Adherence n = 40	High Adherence n = 83	*p*-Value
Obese	25 (16.7%)	8 (29.6%)	5 (12.5%)	12 (14.5%)	
Spirometry					
FEV1	43.8 ± 15.69	45.9 ± 14.47	39.3 ± 15.99	45.3 ± 15.6	0.107
FVC	68.4 ± 20.08	69.4 ± 17.70	63.2 ± 22.87	70.6 ± 19.15	0.160
FEV1/FVC	60.3 ± 10.66	60.4 ± 1.64	57.2 ± 12.33	61.7 ± 9.48	0.085
mMRC	2.47 ± 1.047	2.44 ± 0.934	2.65 ± 1.027	2.40 ± 1.09	0.454
Adherence					
Yes	86 (57.3%)	-	3 (7.5%)	83 (100%)	0.000
No	64 (42.7%)	27 (100%)	37 (92.5%)	-	
Days in the program	55.1 ± 28.10	14.8 ± 9.542	46.5 ± 18.06	72.3 ± 19.54	0.000
Number of sessions	17.9 ± 8.594	4.93 ± 1.900	12.6 ± 2.685	24.6 ± 3.76	0.000
Adherence Rating	-	27 (18.0%)	40 (26.7%)	83 (55.3%)	0.000
Adherence Percentage	74.6 ± 35.81	20.5 ± 7.92	52.7 ± 11.19	102.8 ± 15.6	0.000

FEV1: Forced Expiratory Volume in the first, second FVC: Forced Vital Capacity FEV1/FVC: Ratio between FEV1 and FVC BMI: Body Mass Index mMRC: modified Medical Research Council. ** Post hoc tests: statistically significant differences $p < 0.05$ of the high adherence group concerning the moderate adherence group.

Concerning functional capacity, there was a statistically significant difference in SpO2 for the resting being: 92.6 ± 2.93, 94.7 ± 2.29, and 93.6 ± 3.05 in the low, moderate, and high adherence groups, respectively (*p*-value = 0.012). The group that obtained the most significant distance covered was the high adherence group with 293.1 ± 119.3 m (*p*-value = 0.524) (Table 3).

Table 3. Differences in the functional capacity test (6MWT) of COPD patients adherent and non-adherent to PR.

Variables	Total n = 150	Low Adherence n = 27	Moderate Adherence n = 40	High Adherence n = 83	*p*-Value
Distance traveled (mts)	286.5 ± 108.2	265.7 ± 83.1	286.8 ± 99.1	293.1 ± 119.3	0.524
Distance traveled 350					
Less than or equal to 350 mts	111 (74.0%)	24 (88.9%)	31 (77.5%)	56 (67.5%)	0.074
Greater than 350 mts	39 (26.0%)	3 (11.1%)	9 (22.5%)	27 (32.5%)	
Distance traveled 150					
Less than 150 m	15 (10.0%)	2 (7.4%)	3 (7.5%)	10 (12.0%)	0.639
Between 150–249 m	37 (24.7%)	9 (33.3%)	11 (27.5%)	17 (20.5%)	
250 m or more	98 (65.3%)	16 (59.3%)	26 (65.0%)	56 (67.5%)	
Predicted distance (mts)	456.5 ± 69.7	445.0 ± 53.8	455.0 ± 68.0	461.0 ± 75.1	0.581
predicted distance (%)	62.6 ± 21.9	59.5 ± 16.2	63.6 ± 21.8	63.1 ± 23.6	0.720
Resting Hr 6MWT (bpm)	82.6 ± 12.7	86.6 ± 12.1	82.8 ± 12.7	81.2 ± 12.8	0.165
Hearth rate Recovery					
Adequate	49 (32.7%)	8 (29.6%)	14 (35.0%)	27 (32.5%)	0.899
Inadequate	101 (67.3%)	19 (70.4%)	26 (65.0%)	56 (67.5%)	
Final Hr 6MWT (bpm)	106.3 ± 15.0	108.5 ± 15.1	106.3 ± 12.3	105.6 ± 16.2	0.678
Hr 1 min final 6MWT (bpm)	93.6 ± 15.4	95.5 ± 15.5	94.3 ± 13.5	92.7 ± 16.4	0.687
Hr recovery	12.6 ± 10.3	13.0 ± 10.4	12.0 ± 9.34	12.9 ± 10.8	0.883

Table 3. *Cont.*

Variables	Total n = 150	Low Adherence n = 27	Moderate Adherence n = 40	High Adherence n = 83	*p*-Value
Hr 5 min' end 6MWT (bpm)	84.6 ± 12.8	85.9 ± 12.8	86.1 ± 11.4	83.5 ± 13.4	0.487
SpO2 Rest 6MWT (%)	93.7 ± 2.91 **	92.6 ± 2.93 **	94.7 ± 2.29 **	93.6 ± 3.05 **	0.012
SpO2 end 6MWT (%)	88.1 ± 5.91	87.7 ± 5.82	88.7 ± 5.85	87.9 ± 6.02	0.741
Desaturation percentage	5.75 ± 4.62	5.15 ± 3.95	6.03 ± 4.68	5.82 ± 4.81	0.737
SpO2 1 min final 6MWT	91.4 ± 4.93	90.3 ± 5.03	92.2 ± 4.46	91.5 ± 5.09	0.307
SpO2 5 min final 6MWT	93.7 ± 3.17	92.8 ± 2.81	94.4 ± 3.21	93.7 ± 3.21	0.125
Rr Resting 6MWT (rpm)	20.2 ± 7.45	19.4 ± 3.68	19.5 ± 3.16	20.8 ± 9.54	0.555
Final Rr 6MWT (rpm)	26.5 ± 4.61	26.6 ± 4.27	26.5 ± 4.96	26.4 ± 4.59	0.962
Rr 1 min final 6MWT (rpm)	24.5 ± 7.61	23.5 ± 3.40	24.0 ± 4.25	25.0 ± 9.61	0.609
Rr 5 minutes' end 6MWT (rpm)	20.4 ± 3.64	20.8 ± 2.99	20.5 ± 3.04	20.3 ± 4.10	0.777
Stops 6MWT	0.40 ± 0.724	0.44 ± 0.698	0.45 ± 0.714	0.36 ± 0.742	0.770
Vo2e 6MWT (mL/kg/min)	7.96 ± 2.060	7.81 ± 1.554	8.180 ± 1.76	7.90 ± 2.330	0.730
Meter 6MWT	2.27 ± 0.585	2.23 ± 0.447	2.33 ± 0.504	2.25 ± 0.660	0.718

6MWT: 6-min walk test Hr: Heart rate SpO2: Peripheral oxygen saturation Rr: Respiratory rate VO2e: Estimated oxygen consumption. ** Post hoc tests: statistically significant differences $p < 0.05$ of the moderate adherence group concerning the low adherence group.

Regarding the variables of health-related quality of life, the CRQ-SAS questionnaire found average control of 4.55 ± 1.271; low adherence, 4.64 ± 1.332; moderate adherence, 3.94 ± 1.30; and high adherence, 4.86 ± 1.12 (p-value = 0.007) (Table 4).

Table 4. Differences in health-related quality of life among COPD patients.

Variables	Total n = 150	Low Adherence n = 27	Moderate Adherence n = 40	High Adherence n = 83	*p*-Value
HAD Anxiety	6.23 ± 4.472	5.78 ± 4.484	6.65 ± 4.306	6.17 ± 4.58	0.727
HAD Depression	5.20 ± 3.848	5.52 ± 3.457	5.93± 4.29	4.75 ± 3.72	0.254
CRQ-SAS Dyspnea	3.85 ± 1.443	3.68 ± 1.658	3.71 ± 1.439	4.01 ± 1.36	0.560
CRQ-SAS Fatigue	4.40 ± 1.291	4.09 ± 1.259	4.36 ± 1.303	4.56 ± 1.29	0.362
CRQ-SAS Emotional	4.86 ± 1.250	4.80 ± 1.379	4.54 ± 1.441	5.06 ± 1.04	0.202
CRQ-SAS Control	4.55 ± 1.271 **	4.64 ± 1.332 **	3.94 ± 1.30 **	4.86 ± 1.12 **	0.007
CRQ-SAS Average	3.60 ± 1.943	3.62 ± 1.892	3.53 ± 1.768	3.63 ± 2.07	0.973
SGRQ Symptoms	48.6 ± 19.00	47.2 ± 13.66	49.4 ± 19.22	48.8 ± 20.3	0.921
SGRQ Activities	61.6 ± 23.44	62.0 ± 26.98	63.2 ± 24.81	60.9 ± 22.2	0.909
SGRQ Impact	40.0 ± 18.77	40.8 ± 21.62	41.6 ± 18.63	39.2 ± 18.2	0.850
SGRQ Total	49.8 ± 17.13	50.0 ± 19.52	51.3 ± 18.11	49.3 ± 16.3	0.885

HADS: Hospital Anxiety and Depression Scale CRQ-SAS: Chronic Respiratory Questionnaire, SGRQ: Saint George Respiratory Questionnaire. ** Post hoc tests: statistically significant differences $p < 0.05$ of the high adherence group to the moderate adherence group.

The most common causes of abandonment of the PR program were medical recommendations that prevented 26 patients (17.3%) from continuing in the program due to clinical and safety issues. The group with the highest drop-out rate was the moderate-adherent (15 patients = 37.5%). Sixteen patients (10.7%) stopped the program due to economic issues (mainly costs to reach the rehabilitation site not affordable). The group with the highest drop-out rate was the low-adherent (37%). Another group of 10 patients (6.7%) dropped out of the program because the insurer changed the location of the patient.

4. Discussion

This investigation describes adherence rates to PR in a cohort of COPD patients in the city of Cali (Colombia) over one year (2020–2021) and shows that the high-adherent group corresponded to 55.3%, the moderate-adherent to 26.7%, and the low-adherent to 18% with an average number of sessions for high adherence of 24.6 ± 3.76. These results are similar to those obtained by Oates et al. [5], which state that the high adherence group has a higher percentage of participation (50.8%) as opposed to the moderate adherence group (23.6%) and the low adherence group (25.5%). This study demonstrates that the number of sessions indicated for high adherence is between 21 and 30.

The most significant number of participants is men diagnosed with COPD linked to a PR program. The high adherence group comprises the highest percentage of men who adhered to the rehabilitation program (67.5%), compared to the percentage of women (32.5%). Oates et al. [5] show in their study a similar scenario where most COPD patients were men (58). This is because the prevalence of the disease is higher in men, as Rojas et al. [6] provide evidence for in their investigation where the estimated prevalence of COPD in Colombia, mainly in men, is 3.55% compared to 3.22% in women in adults over 60 years of age. This fact is because the male sex has a higher prevalence of smoking, which is the main risk factor [7].

High adherence may be more prevalent in men since they are more involved in physical exercise programs than women who follow more self-care recommendations about pharmacological treatment [5,8,9]. The average age of the participants was over 70 years, showing that one of the characteristics of COPD is the late diagnosis and referral to control treatments at an advanced age [2,10]. Therefore, greater dependence on a caregiver might be expected, who can be a facilitator or a constraint to adherence to the PR [11,12]. It should be noted that COPD is diagnosed late in Latin American countries, so patients are referred late to PR programs. The PLATINO study indicates that COPD is underdiagnosed and undertreated [13].

Most of the participants live with their partner, which is similar to what Adhikari et al. [4] found in their study where the cohabitation status of the population linked to a PR program could be related to the fact that people with COPD have limitations in the activities of daily living, causing them to require physical or emotional care support. Therefore, the partner or family members usually take on the role of caregivers and, in turn, influence treatment adherence, as they are responsible for motivating the patient. In addition, they are responsible for transporting and accompanying the patient to the treatment site; the latter can negatively or positively impact adherence [11].

Participants residing in a low socioeconomic stratum presented low adherence. Oates et al. [5] state that low socioeconomic status and lower economic income are associated with low adherence to PR programs because factors such as environmental exposures, transportation conditions, occupational situations, and educational background generate cost overruns or lack of motivation to comply with the stipulated sessions. This study corroborated the above because the low adherence group had the highest percentage of patients in the subsidized regime, implying that they cannot pay the Colombian health system. This leads to more significant difficulties since they must make additional contributions to receive care. In addition, the lower-income population usually has a low educational level, which limits their access to information and the adoption of healthy behaviors [12–15].

Regarding the clinical variables, the group with high adherence presented the highest number of emergency room admissions and hospital admissions. The group with moderate adherence presented the highest number of hospitalized days. These results coincide with those reported by other authors [16], who state that comorbidities are responsible for exacerbations and clinical deterioration, leading to increased emergency room visits and extended hospital stays. Other authors describe that patients at high risk of exacerbations are more likely to receive adequate treatment and better intervention strategies [17]. Thus, patients with high adherence and moderate adherence were hospitalized for more days compared to those with low adherence. This allowed for a better treatment course, as

demonstrated by the study of the inverse relationship between nonadherence to the original GOLD treatment guidelines and COPD exacerbations [18].

Risk factors, such as exposure to wood smoke and smoking, are more significant in the low adherence group. The incidence of these risks is higher because the level of education and low-income limit their access to knowledge about the consequences of these behaviors. The results coincide with those of the PREPOCOL study [3], which establishes that smoking and biomass exposure are the main determinants of the disease. In another study, Amigo et al. [19] provide evidence showing that the participants of low-socioeconomic levels smoke more, which relates to their economic income and educational level [14].

This study found a statistically significant height difference, showing a higher mean in the high adherence group. However, no study has been found that relates the cause of this variable to be significant. Additionally, BMI showed values close to normal and overweight, which could be related to less muscle atrophy and sustained hypoxia during the patients' activities of daily living. This is also expressed by the fact that there were no significant differences between the groups in a functional capacity [20–22]. Patients with these characteristics have received the suggestion to enter an acquisition phase that allows them to maintain a similar BMI even after PR [23].

Concerning pulmonary function variables, the high adherence group presented better FEV1, in agreement with Boim et al. [23], demonstrating that patients who attended all PR program sessions obtained better FEV1 and spirometer values. This could mean less structural deterioration caused by the disease, allowing for the patient to remain under control.

Regarding functional capacity variables, the distance walked in the 6MWT did not show statistically significant differences: the patients with high adherence walked 27.4 m more than those with low adherence. This might be because the patients had certain physical qualities, such as muscular strength in the lower limbs and cardiopulmonary endurance, which allowed them to perform better in the PR program. Similar results have already been described, reporting a difference of 59.1 m in favor of patients with greater adherence [5]. Despite not showing a significant difference, it is noteworthy that the dyspnea mMRC in the high adherence group presented a lower score than that of the other groups, showing a correlation with a greater distance walked in the 6MWT [21,24].

Regarding anxiety and depression, the groups did not present clinical conditions or significant differences. However, the high adherence group obtained the lowest score in the depression domain, presenting a mean of 4.75 ± 3.72.

Concerning health-related quality of life, a statistically significant difference was found in the CRQ-SAS questionnaire in the control domain, evidenced by a better score in the high adherence group. This could be because the adherent patients had previously presented more exacerbations and hospitalized days and adopted safe disease control behaviors. In addition, this group had the financial resources to pay and a better educational level, which allowed them to better cope with the limitations of the disease [5,14].

Although no statistically significant differences were found with the SGRQ questionnaire, patients presented greater activity impairment. This fact is because the questions are related to limitations in the activities of daily living caused by a reduced airflow, generating dyspnea [21].

The most significant cause for dropping out of the PR program was medical recommendation (17.3%) due to clinical and safety issues followed by not having money for transportation (10.7%) to get to the treatment site. These results coincide with those obtained by Pacheco et al. [25], where patients dropped out of a PR program due to transportation issues because of the distance to the center, time, and money, considering that most participants come from a low stratum.

The limitations of this study are related to the pandemic decreed by the WHO and governmental entities from March 2020 to July 2020 generated by the SARS-CoV2/COVID-19 infection. This situation led to reduced adherence to the PR program due to fear of

COVID-19 infection. Therefore, this study addressed population retention strategies, such as telephone follow-ups with patients' families to encourage attendance at scheduled sessions. These results may require more external validity, as only the results of one PR program are reported, which could lead to bias.

Further research may follow up on clinical variables and multidimensional indices to provide more information on mortality and adherence to PR programs [26]. Among the study's strengths is the number of variables considered, as expressed by other authors [5], which provides valuable information to develop PR program adherence strategies.

5. Conclusions

There was a high adherence to pulmonary rehabilitation (57.3%). Increased commitment to the PR program occurred in male patients who could afford the Colombian health system (contributory regime), so they remained longer in the program.

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Data Availability Statement: The dataset used to support the findings of this study have been deposited in the https://figshare.com repository (https://doi.org/10.6084/m9.figshare.21751637.v1), accessed on 19 December 2022.

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