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Short title: Personality and pulmonary rehabilitation

Title: The role of personality traits in inpatient pulmonary rehabilitation response in patients with Chronic Obstructive Pulmonary Disease

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Highlights

- A high level of openness to experiences might be a risk factor of non-response to pulmonary rehabilitation on health-related quality of life in persons with COPD
- Neuroticism, extraversion, conscientiousness and agreeableness were not associated with inpatient pulmonary rehabilitation effectiveness.
- Considering personality traits could be interesting for treatment individualization and optimization.

Summary

Background: The effectiveness of pulmonary rehabilitation (PR) is a critical issue for chronic obstructive pulmonary disease (COPD) patients. However, PR response is marked by a strong heterogeneity, partially unexplained to date. We hypothesized that personality traits defined by the Five-Factor Model could modulate the effect of inpatient-PR. **Objective:** The aim was to assess the associations between these five personality traits and PR outcomes. **Methods:** 74 persons with COPD admitted for a 5-week inpatient PR program had a personality assessment at the start of the program (T1). Exercise capacity, quality of life, sensory and affective dyspnea dimensions were assessed at T1 and at the end of the program (T2). Their evolution was evaluated using the delta score between T2 and T1. PR response was defined using the minimal clinically important change score for each of them. A composite response was established distinguishing the poor responders' group, made of patients who responded to 0, 1 or 2 parameters and the good responders' group, with patients who responded on 3 or 4 indicators. **Results:** Logistic regressions analyses highlighted that those with a high level of openness [OR=0.36, 95% CI=0.15 – 0.74, $p<.01$] were less likely to respond on quality of life, controlling for socio-demographic factors and the severity of the disease. **Conclusion:** This study shows that the investigation of the personality constitutes an interesting perspective for better understanding the interindividual differences observed between patients in the PR response. Tailoring clinical intervention to the patient's personality could be a promising prospect for optimizing PR effectiveness.

Keywords: Five Factor Model, Personality, Pulmonary rehabilitation, Respiratory Diseases, Response, Therapeutic Outcomes

Introduction

Pulmonary rehabilitation (PR), the reference treatment for people with chronic respiratory diseases (CRDs), is a comprehensive and multidisciplinary intervention aiming to improve both the physical and psychological health of patients, as well as specific symptoms of the disease [1]. Despite a large body of research demonstrating that PR generates numerous bio-psychosocial benefits [2-4], it reported a significant heterogeneity in PR response [5-8]. Overall, these studies highlighted that between one-third to one-half of patients enrolled in a PR program exhibited no clinically significant improvement at the end of the PR program on various clinical outcomes including exercise capacity and quality of life [5,8]. Given the key role of PR in CRDs management, the identification of factors associated with PR outcomes has been widely investigated in the literature [9-12]. However, the understanding of this PR response heterogeneity remains incomplete, particularly since most studies were essentially limited to investigating the influence of intrinsic parameters (e.g., forced expiratory volume in 1 second at the beginning of the program). Yet, extrinsic factors, such as therapeutic environment, and above all the way patients interact with it, could also notably influence PR effectiveness. This could be particularly relevant in the specific context of inpatient PR, characterized by i) a rupture with the patient's home environment lasting several weeks, ii) being confronted with new social rules and norms and iii) a new community life with other people suffering from CRD's and a variety of healthcare professionals. All patients, depending on their psychological predispositions, might adapt differently to a PR environment and thus, might not gain the same benefits from the therapeutic care management. For example, introvert patients could have greater difficulties progressing correctly in collective activities whereas, extroverts could benefit more from activities providing opportunities for social interaction. Thus, the heterogeneity observed in PR response could partly be the reflection of this adequation between PR environment and one's tendency to act, think and feel, i.e. personality traits. According to the Five Factor Model [13,14], personality is made of five dimensions present in varying degrees in individuals and influencing their behavior and life experiences [15]. These five traits include Neuroticism (i.e., tendency to be emotionally unstable and stressed), Extraversion (i.e., tendency to be optimistic and dynamic), Openness to experience (i.e., tendency to look for new experiences), Agreeableness (i.e., tendency to be altruistic) and Conscientiousness (i.e., tendency to be self-disciplined). Previous studies showed that these personality traits were associated with some PR-specific environmental elements. For example, personality was associated with the development of therapeutic alliance [16], quantity and quality of social interpersonal interactions [17], respecting authority [18] and assimilation of cultural social

norms [19]. Personality traits were also associated with treatment observance and compliance [20-22], effectiveness of non-pharmacological interventions [23], and participation to rehabilitation activities [24]. Moreover, the association between personality traits and physical activity has been established [25,26]. Thus, these studies suggested that personality traits, given their relationships with PR elements, could influence the way patients adapt to a PR environment. In fact, personality could become an explanatory psychological factor for interindividual differences observed in PR response. This is why, we hypothesized that personality traits could be associated with the effectiveness of inpatient-PR. Therefore, the objective of the present study was to investigate associations between the five personality traits and PR response in persons with chronic obstructive pulmonary disease.

Material and methods

Ethics approval

The study protocol was approved by an independent French ethics committee (CPP Ouest IV Nantes, reference number: 2018-A03141-54, 03/04/2019). The present study abided by the principles of the Declaration of Helsinki for human experimentation of 1975, revised in 2000.

Data accessibility

Individual values for all supporting data are available upon request.

Participants and procedure

Patients were recruited during a 5-week inpatient PR program at the “Clinique du Souffle La Vallonie” (Lodève, France), between April 2019 and January 2020. Patients were eligible for the study if they: 1) had a validated diagnosis of chronic obstructive pulmonary disease (COPD), 2) were older than 18 years old and 3) had healthcare coverage. Patients were not included in the study if they were unable to respond to paper-based questionnaires and/or if they had a mental disorder that could affect their judgment. Eligible participants were invited to participate in this study during an inclusion visit (T0) that took place during the first two days of the program. No intervention or incentive was provided to encourage study participation. In accordance with the regulations governing research displayed in 3 ° of article L.1121-1 of the French public health code concerning non interventional studies based only on questionnaires or interviews, a declaration of non-opposition to participating in the study was collected from all participants before inclusion. Patients were recruited on a voluntary basis, after medical advice and checking all criteria mentioned above. Patients enrolled in the study

were assessed twice, during the first week (T1) and at the end of the last week of the PR program (T2). The mean time interval between T1 and T2 was 25 days (Standard deviation = 5 days).

Pulmonary rehabilitation

The inpatient PR program was conducted following recommendations of the American Thoracic and European Respiratory societies [1]. The program was carried out over 5 weeks. Patients received a complete clinical evaluation (clinical assessment, respiratory function measures at rest by plethysmography, blood gas test, and body composition) and benefited from 30 to 40 sessions of exercise training including endurance training (average of 7h/wk.) and resistance training both for upper and lower limbs (average of 2h/wk.). Exercises focused on balance, coordination, flexibility and posture. Furthermore, collective relaxation sessions (on average 4 hours / week) were also offered. In addition, participants had access to group therapeutic education sessions (e.g., pain and dyspnea self-management, smoking cessation, behavioral change, physical activity planning...) and nutrition, psychological and nursing support in individual sessions (average of 3 hours / wk.). Average PR duration in our sample was 35 days (SD=4 days).

Measures

Personality traits

Personality traits of the Five-Factor model were measured at T1 using the French version of the Big Five Inventory (BFI-Fr) [27]. Participants were asked whether they agreed or disagreed with 45 descriptive statements using a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Eight items assessed the level of extraversion (e.g., "*I see myself as someone who is sociable*") and neuroticism (e.g., "*I see myself as someone one who is easily anxious*") in participants. Nine items measured the level of conscientiousness (e.g., "*I see myself as someone who is effective in his work*"). Finally, answers on ten items assessed the level of openness to experiences, (e.g., "*I see myself as someone creative, full of original ideas*"), as well as agreeableness (e.g., "*I see myself as someone who is naturally forgiving*"). A high score in a specific trait indicates a high level on that trait. In the sample, Cronbach alphas, measuring the internal consistency of the 5 scales, were .77 for neuroticism, .73 for extraversion, .85 for openness, .68 for agreeableness, and .65 for conscientiousness.

Sociodemographic, anthropometric and clinical characteristics

Collected demographics included self-reported age (in years), sex (coded 0 for men and 1 for women) and education (in years). Anthropometric data included height (cm), weight (kg), which led to calculating the body mass index (BMI) (kg.m^{-2}). Deprivation was measured using the EPICES (Evaluation of Deprivation and Inequalities in Health Examination Centers) score [28], calculated from weighted scoring of answers to 11 questions pertaining, for example, to health insurance, home ownership, financial situation. The final EPICES score ranged from 0 to 100. Clinical characteristics included pulmonary and cognitive function assessments. Regarding pulmonary function assessment, forced expiratory volume at the first second of maximum expiration (FEV₁), its predicted value (FEV₁ % pred) and Tiffeneau index (FEV₁ / FVC) were measured with a plethysmograph (V6200 Autobox, SensorMedics Corp., Yorba Linda, CA, USA). Cognitive impairment was assessed with the Montreal Cognitive Assessment (MoCA) test [29]. A score above or equal to 26 on a 0–30-point scale was considered normal. All of these variables were assessed at T1.

Exercise capacity

Exercise capacity was assessed at T1 and at T2 with a 6-minute walking test (6MWT) at the start and at the end of PR, respectively. In accordance with good clinical practices and the guidelines of the American Thoracic Society [1] patients were instructed to walk as far as possible in 6 minutes, in a 30-meter corridor.

Quality of life

Health-related quality of life was measured at T1 and at T2 with the short French self-reported questionnaire VQ11, specific to COPD [30]. This questionnaire includes 11 items related to feelings experienced in dealing with consequences of the disease. Each participant indicated the intensity experienced for each feeling on a scale ranging from 1 (not at all) to 5 (extremely). This questionnaire enables the calculation of the overall health-related quality of life score and 3 sub-dimensions: functional, psychological and relational scores. The VQ11 score ranges from 11 to 55 and a low global score (< 22) indicates a better health-related quality of life.

Dyspnea

Dyspnea was assessed at T1 and at T2 using the French version of the "Multidimensional dyspnea profile" questionnaire (MDP) [31-33]. The MDP consists of 11 items evaluated on an analog scale ranging from 0 (*not felt*) to 10 (*strongly felt*). This questionnaire evaluates 3 subdomains of dyspnea. The first item (A1) assesses the immediate unpleasantness of the

dyspnea. Then, five items (SQ) measure sensations linked to dyspnea, both in terms of quality and intensity. The last five items (A2) assess emotions arising from experiencing dyspnea, in terms of quality and intensity. From these scores, two components of dyspnea can be calculated: the sensory dimension (MDP-SD) of dyspnea, corresponding to the sum of the 5 items from the SQ, and affective dimension (MDP-AD) of dyspnea calculated by adding A1 and A2. To complete the questionnaire, patients were instructed to focus on the worst episode of dyspnea experienced over the past two weeks.

Effect of pulmonary rehabilitation

Evolution of clinical indicators during PR

The effects of respiratory rehabilitation were studied via the evolution of the 6MWT distance and VQ11, MDP-SD and MDP-AD scores. The evolution of these clinical indicators was evidenced by the delta calculated by subtracting values at T1 from values at T2. In order to promote the readability of the results, all values were expressed in absolute values. Therefore, a positive score denotes an improvement of the parameters while a negative score represents a deterioration.

Categorization of COPD patients according to PR response

- Responders vs. Non-Responders

Responders and non-responders were differentiated using the Minimal Clinically Important Difference (MCID) available for each indicator in the literature. These MCIDs and associated reference studies are listed in Table 1.

- Good-Responders vs. Poor-Responders

In order to best reflect the multidisciplinary objectives of the PR, a composite response was defined based on the previous distinctions from the assessment of physical and psychological indicators. Patients were therefore classified into 2 response profiles: the “poor responders” group, consisting of patients who only responded on 0, 1 or 2 parameters according to the respective MCIDs and the “good responders” group, where patients showed a clinically significant improvement on 3 or 4 indicators.

Table 1. Minimal Clinically Important Differences defined for 6MWT, VQ11, MDP-SD and MDP-AD.

Indicators		MCIDs	References
6MWT		+ 30 meters	[34,35]
VQ11		- 2 points	[36]
MDP-SD		- 3.02 points	[37]
MDP-AD	A1	- 0.58 point	
	A2	and/or - 2.07 points	

Data analyses

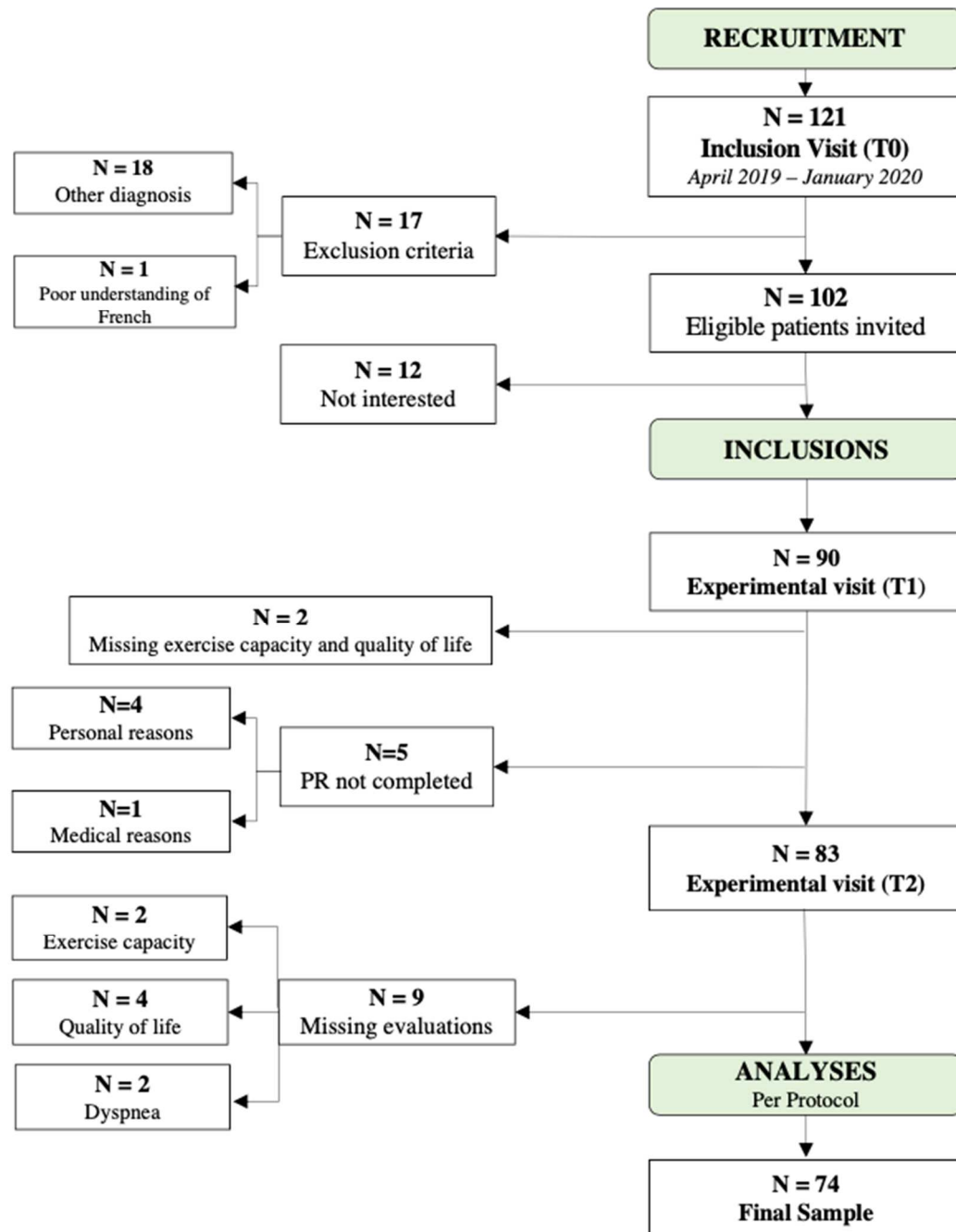
To test whether the five personality traits were associated with the evolution of clinical indicators (i.e., 6MWT, VQ11, MDP-SD, MDP-AD) during PR, multiple linear regression analyses were performed, adjusted for relevant demographic and clinical information: age (in years), sex (coded as 1 for men and 0 for women), educational attainment (in years), %FEV1, MoCA score, EPICES score and value at baseline. For these analyses, we used the `lm()` function of “stats” package in R studio software.

Furthermore, to test associations between the five personality traits and response on each clinical indicator, logistic regressions analyses were carried out, adjusted for age, sex, educational attainment, %FEV1, MoCA score, EPICES score and score at baseline. For each indicator, the responder group was recoded as 1 while the non-responder group was recoded as 0. For these analyses, we used the `glm` function of “stats” package in R studio software.

Moreover, independent sample t-tests and chi-squared analyses were performed to examine baseline differences between responders and non-responders on composite PR response regarding socio-demographics, anthropometrics, pulmonary function characteristics and clinical indicators. Additional logistic regression analyses were used to test relationships between PR composite response and the five personality traits, adjusted for relevant demographics and clinical elements: age, sex, education, %FEV1, MoCA score, and the EPICES score. For these analyses the "good response" group was recoded as 1 while the "poor response" group was recoded as 0. Taking into account the high number of statistical tests carried out, we chose to lower the significance level at $p \leq .01$, in order to limit the risk of type I error. Patients who did not complete the PR program or patients with incomplete data were excluded from the analyses. A flowchart is presented in figure 1. For all outcomes, personality scores were standardized and analyses were conducted separately for each trait and then with

all traits simultaneously within the same model. All statistical tests were carried out with R and R studio software. The R studio script is available upon request.

Figure 1. Flow Chart



Results

Patient characteristics

Among the 121 patients invited to participate in the present study, 102 met the inclusion criteria and 90 agreed to participate. Five patients did not complete the rehabilitation program and 11 patients did not complete all the evaluations. As such, the final sample included 74 persons with COPD (Figure 1). Baseline characteristics of participants are reported in Table 2. Values are represented by the mean \pm standard deviation in case of normal distribution (test with Q-Qplot, Skewness, Kurtosis), otherwise by the median [lower quartile (LQ)- upper quartile (UQ)].

Table 2. Descriptive characteristics of the sample

Variables	Mean / Median	Standard Deviation / [LQ-UQ]
<i>Demographic and anthropometric</i>		
Sex n women (%)	29 (39%)	-
Age (years)	68.39	8.64
BMI (kg.m ²)	24.10	[20.61 - 28.30]
Education (years)	12.32	3.59
EPICES	22.77	[13.61 - 35.51]
<i>Pulmonary Function</i>		
FEV ₁ (L)	0.95	[0.80 - 1.18]
FEV ₁ (% pred)	38.30	[31.00 - 49.75]
FEV ₁ /FVC (%)	45.36	[37.93 - 50.81]
GOLD stage I n (%)	6 (8%)	-
GOLD stage II n (%)	14 (19%)	-
GOLD stage III n (%)	37 (50%)	-
GOLD stage IV n (%)	17 (23%)	-
<i>Psycho-cognitive variables</i>		
MOCA score	25	[23.00 - 27.00]
	Score 26 < n = 50 (68%)	
VQ11	34.30	7.92
MDP-SD	30.59	9.46
MDP-AD	28.50	[19 - 43.75]
<i>Exercise capacity</i>		
6MWT (in meters)	370.39	85.78
<i>Personality traits</i>		
Neuroticism	2.58	0.75
Extraversion	3.12	0.68
Openness	3.45	0.76
Agreeableness	4.14	0.46
Conscientiousness	3.84	0.52
Note. Total N = 74 , BMI: body mass index, FEV ₁ : forced expiratory volume in one second; FVC: forced vital capacity; GOLD : global initiative for chronic obstructive lung disease		

Evolution of clinical indicators during PR and associations with personality traits

The evolution of each clinical indicators during PR is presented in table 3. The results of multiple linear regression analyses performed to test the association between personality traits and the evolution of clinical indicators during PR are presented in Table 4. These analyses did not highlight any significant association between personality traits and the evolution of exercise capacity, quality of life, sensory and affective dyspnea dimensions. Furthermore, no significant association was found when all traits were simultaneously entered in the same model (Table S1).

Table 3. Evolution of clinical indicators during PR

Variables	T1 (Start of PR)	T2 (End of PR)	Δ
	Mean ± Standard Deviation		
	Median [LQ;UQ]		
6MWT	371.43 ± 85.02	409.99 ± 90.75	36.50 [10.50; 61.50]
VQ11	34 [29.25;39.00]	29 [22.00; 34.00]	6 [2.00; 9.75]
MDP-SD	31 [24.00; 38.00]	22 [13.25; 32.00]	8 [1.25; 17]
MDP-AD	28.50 [19.00; 30.45]	17 [11.00; 25.00]	8 [-1.00; 23.50]

Note. LQ: lower quartile, UQ: upper quartile

Δ : relative difference between T2 and T1 score

Table 4. Summary of multiple regression analyses predicting the evolution of clinical indicators during PR from personality traits in baseline

Variables	Δ 6MWT	Δ VQ11	Δ MDP-SD	Δ MDP-AD
	β p-values			
Neuroticism	0.08 _{ns} p=0.50	-0.01 _{ns} p=0.93	-0.12 _{ns} p=0.24	-0.12 _{ns} p=0.26
Extraversion	-0.08 _{ns} p=0.51	-0.06 _{ns} p=0.56	0.23 _{ns} p=0.02	0.11 _{ns} p=0.24
Openness	-0.01 _{ns} p=0.92	-0.16 _{ns} p=0.12	0.23 _{ns} p=0.03	0.16 _{ns} p=0.07
Agreeableness	-0.15 _{ns} p=0.24	-0.01 _{ns} p=0.93	0.07 _{ns} p=0.52	0.14 _{ns} p=0.15

Conscientiousness	-0.04 ^{ns} <i>p</i> =0.74	0.06 ^{ns} <i>p</i> =0.54	0.00 ^{ns} <i>p</i> =0.96	-0.05 ^{ns} <i>p</i> =0.55
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Note. Adjusted for age, sex, %FEV1, MoCA score, EPICES score, Education and T1 score

^{ns} = not significant according to the significance level defined at $p \leq 0.01$

Δ : delta between T2 and T1 score

No significant association was found when all traits were simultaneously entered in the same model.

Responders vs. Non-Responders and associations with personality traits

According to MCIDs of exercise capacity during the program, 42 (57%) patients were categorized as responders, and 32 (43%) as non-responders. For health-related quality of life, 59 (80%) COPD patients were classified as responders. For dyspnea, 50 (68%) and 58 (78%) patients were classified as responders on MDP-SD and MDP-AD respectively.

Logistic regression analyses revealed a significant association between openness and VQ11 response. Specifically, this result suggested that a high level of openness [OR = 0.36; 95% confidence interval (CI) = 0.15 – 0.74] was associated with a lesser likelihood of responding on the VQ11 (Table 5). This relation did not remain significant when all traits were simultaneously entered into the adjusted logistic regression model (Table 6). No association between personality traits and 6MWT, MDP-SD and MDP-AD responses were found.

Table 5. Summary of logistic regression analyses predicting clinical indicators response from personality traits in baseline

Variables	Response to 6MWT	Response to VQ11	Response to MDP-SD	Response to MDP-AD
	<i>Odd Ratios</i> <i>95% CI</i> <i>p-values</i>			
Neuroticism	0.99 ^{ns} (0.59-1.69) <i>p</i> =0.97	1.01 ^{ns} (0.51-2.08) <i>p</i> =0.97	0.71 ^{ns} (0.37-1.29) <i>p</i> =0.26	0.67 ^{ns} (0.30-1.47) <i>p</i> =0.32
Extraversion	0.57 ^{ns} (0.30-0.99) <i>p</i> =0.06	0.69 ^{ns} (0.33-1.33) <i>p</i> =0.29	1.86 ^{ns} (0.98-3.77) <i>p</i> =0.07	1.35 ^{ns} (0.64-2.96) <i>p</i> =0.44
Openness	1.08 ^{ns} (0.65-1.82) <i>p</i> =0.76	0.36* (0.15-0.74)	2.11 ^{ns} (1.10-4.50) <i>p</i> =0.03	2.69 ^{ns} (1.27-6.81) <i>p</i> =0.02
Agreeableness	0.96 ^{ns} (0.54-1.66) <i>p</i> =0.88	0.98 ^{ns} (0.50-1.87) <i>p</i> =0.94	1.72 ^{ns} (0.91-3.45) <i>p</i> =0.10	2.45 ^{ns} (1.11-6.27) <i>p</i> =0.04
Conscientiousness	0.78 ^{ns} (0.46-1.29) <i>p</i> =0.34	0.59 ^{ns} (0.30-1.07) <i>p</i> =0.09	1.79 ^{ns} (0.95-3.60) <i>p</i> =0.08	1.78 ^{ns} (0.95-3.63) <i>p</i> =0.09

Note. Coefficients are standardized regression coefficients. 95% confidence intervals are in parentheses. Adjusted for age, sex%,FEV1, MoCA score, EPICES score, Education and T1 score
 * $p < .01$, ns = not significant according to the significance level defined at $p \leq .01$

Table 6. Summary of logistic regression analyses predicting clinical indicators response from the five personality traits included in the same regression model

Variables	Response to 6MWT	Response to VQ11	Response to MDP-SD	Response to MDP-AD
	<i>Odd Ratios</i> <i>95% CI</i> <i>p-values</i>			
Neuroticism	0.83 ns (0.43-1.57) $p=0.55$	0.49 ns (0.17-1.31) $p=0.17$	1.32 ns (0.58-3.27) $p=0.51$	1.38 ns (0.49-4.50) $p=0.56$
Extraversion	0.49 ns (0.24-0.91) $p=0.03$	0.91 ns (0.39-2.11) $p=0.82$	1.75 ns (0.80- 4.16) $p=0.18$	1.48 ns (0.55-4.61) $p=0.46$
Openness	1.44 ns (0.78-2.77) $p=0.25$	0.26 ns (0.07-0.68) $p=0.02$	1.53 ns (0.71- 3.58) $p=0.29$	2.19 ns (0.93-6.14) $p=0.10$
Agreeableness	0.81 ns (0.41-1.55) $p=0.53$	1.30 ns (0.54-3.20) $p=0.55$	1.76 ns (0.8- 4.23) $p=0.17$	2.41 ns (0.92-8.14) $p=0.10$
Conscientiousness	0.75 ns (0.42-1.30) $p=0.31$	0.60 ns (0.28-1.22) $p=0.16$	1.35 ns (0.67-2.85) $p=0.41$	1.19 ns (0.53-2.75) $p=0.67$

Note. Coefficients are standardized regression coefficients. 95% confidence intervals are in parentheses. Adjusted for age, sex%,FEV1, MoCA score, EPICES score, Education and T1 score
 ns = not significant according to the significance level defined at $p \leq .01$

Good Responders vs. Poor Responders and associations with personality traits

Based on the composite response criteria defined in this study, 47 (62%) patients were classified as good responders and 27 (38%) as poor responders. Descriptive statistics for each group are presented in Table 7.

The independent sample t-tests and chi-squared performed to compare baseline characteristics between each group did not reveal any significant difference on socio-demographic, anthropometric, pulmonary function, and exercise capacity variables (Table 7). Regarding psycho-cognitive variables, good responders had significantly higher scores on the MDP-AD [$M_{\text{goodresponders}} = 33$ [21.50 - 46.50] versus $M_{\text{poorresponders}} = 22$ [14.50 - 28.50]; $W(72) = 405.5$, $p = <.01$], indicating a poorer affective dimension of dyspnea at baseline (Table 7).

Logistic regressions did not unveil a significant association between personality traits and PR composite response (Table 8). No significant association was found when all traits were simultaneously entered in the same model (Table S2).

Table 7. Patient characteristics according to Poor or Good Responder Profile

Variables	Poor responders n = 27	Good responders n = 47	p-values
Demographic and anthropometric variables			
Sex n(% women)	10 (37%)	19 (40%)	.77ns
Age (years)	69.11 ± 10.85	67.98 ± 7.18	.63ns
BMI (kg.m ²)	24.31 [19.35-27.15]	23.89 [21.33-28.45]	.68ns
Education (in years)	12.09 ± 3.90	12.45 ± 3.43	.70ns
EPICES score	22.48 [13.61-29.97]	23.07 [13.61-39.64]	.48ns
Pulmonary Function variables			
FEV ₁ (L/min)	0.95 [0.74-1.14]	0.95 [0.82 -1.92]	.78ns
FEV ₁ (% pred)	37 [31-48.50]	40 [30 -50.02]	.78ns
FEV ₁ /FVC (%)	45.65 [35.36-51.75]	45.26 [39.51-50.31]	.84ns
GOLD stage I n (%)	1 (2%)	3 (6%)	.42ns
GOLD stage II n (%)	5 (26%)	19 (21%)	-
GOLD stage III n (%)	16 (46%)	59 (45%)	-
GOLD stage IV n (%)	5 (26%)	19 (28%)	-
Psycho-cognitive variables			
MOCA score	25.19 ± 2.80	24.85 ± 3.02	.63ns
VQ11	32.22 ± 7.95	35.49 ± 7.74	.09ns
MDP-SD	28[23.50 -32.50]	34[26.50-39]	.03ns
MDP-AD	22[14.50 -28.50]	33[21.50-46.50]	.01*
Exercise capacity			
6MWT (in meters)	381.07 ± 71.24	365.89 ± 92.29	.43ns
Note. BMI: body mass index, FEV ₁ : forced expiratory volume in one second; FVC: forced vital capacity; TLC: total lung capacity; GOLD: global initiative for chronic obstructive lung disease * $p < .01$, ns = not significant according to the significance level defined at $p \leq .01$			

Table 8. Summary of logistic regression analyses predicting PR composite response from personality traits at baseline

Variables	Response to PR (Poor Responders = 0 and Good Responders = 1)
	Odds Ratios 95% CI p-values
Neuroticism	1.15ns (0.70-1.94) $p=0.57$

Extraversion	0.87 _{ns} (0.51-1.45) <i>p</i> =0.59
Openness	1.26 _{ns} (0.77-2.12) <i>p</i> =0.37
Agreeableness	1.17 _{ns} (0.68-2.01) <i>P</i> =0.57
Conscientiousness	1.09 _{ns} (0.66-1.78) <i>p</i> =0.74

Note. Coefficients are standardized regression coefficients. 95% confidence intervals are in parentheses. Adjusted for age, sex, %FEV1, MoCA score, EPICES score and Education
_{ns} = not significant according to the significance level defined at $p \leq .01$
No significant association was found when all traits were simultaneously entered in the same model.

Discussion

The objective of the present study was to assess, for the first time, relationships between personality traits, as defined by the Five-Factor Model, and effectiveness of inpatient-PR on exercise tolerance, quality of life and dyspnea in persons with COPD. Consistent with our hypothesis, this study shows that personality traits are likely to modulate the effectiveness of the therapeutic intervention. In particular, a high level of openness to experience was associated with a lesser likelihood of responding to PR on quality of life. No association was found between the other traits and PR outcomes. In addition, none of the traits were associated with PR composite response.

Thus, our study suggests that openness to experiences could be a risk factor for non-response to PR on quality of life. This result was unexpected because most studies that identified links between openness and therapeutic intervention effectiveness usually reported that this trait was a protective factor [38-40]. For example, a high level of openness increases the benefits from a nonpharmacological breathlessness intervention in persons with intrathoracic cancer [39]. In addition, it was positively associated with intervention effectiveness for cognitive impairment in older adults [40] and with decreased depression severity upon treatment completion [38]. Regarding quality of life, the few studies that investigated the relationship with openness to experiences following a clinical intervention reported inconsistent results. For example, while a high level of openness was significantly

associated with a poorer quality of life 6 months after breast reconstruction [41], no association was evidenced in women with Breast Cancer 1 and 2 mutations, after risk-reducing salpingo-oophorectomy [42]. This lack of consensus might be explained by the fact that these associations could be related to contextual factors. Indeed, our results can partly be interpreted in light of the very specific context of inpatient-PR, which could interfere with the psychological needs of these individuals. For example, the highly supervised environment of inpatient PR imposes some restrictions (i.e., monitored outings and visits, strict daily schedule...), which do not align with the personal values of independence in thoughts and actions of individuals with a high level of openness [43]. Moreover, repeating the same activities during a 5-week period could create a routine, lacking stimulation for those individuals constantly looking for new and unusual experiences [14]. Therefore, the poor match between the openness trait and inpatient-PR environment specificities could interfere with the effectiveness of the therapeutic intervention. To test the validity of this hypothesis, it could be interesting to identify whether these associations between openness and PR response would be similar in the context of more independent therapeutic modalities such as outpatient or home-based program.

The lack of associations with the other traits of the Five-Factor Model in the present research is surprising since previous studies, investigating the role of personality in chronic disease [23,44] or mental health [45-47] clinical outcomes, showed that neuroticism [23,44-47], conscientiousness [44,46,47], extraversion and agreeableness [44,46] were likely to modulate the effect of therapeutic management. To date, few studies have investigated the mediating mechanisms underlying which traits could influence response to treatment [48]. However, consistent associations between traits and behaviors that could influence a therapeutic management, such as adherence to treatment protocol [20,21,49-51] were identified. Nevertheless, the context of inpatient-PR, given these constraining characteristics (i.e., supervision by a multitude of healthcare professionals, care setting rules) offers few opportunities for patients to express their own individual behavioral patterns. Inpatient-PR could thus constitute a poor environment for the expression of these personality traits. In order to test this hypothesis, it might be interesting to identify associations between personality traits and more specific behaviors such as PR program dropout rates, level of engagement in therapeutic management or participation in sessions. Moreover, future studies should investigate the associations between personality traits and PR response in management settings where individual patient behaviors (e.g., therapeutic adherence) are central to the success of the program such as outpatient-PR or telerehabilitation.

In addition to the scientific relevance of improved understanding of psychological factors that may influence PR effectiveness [52-55], the results could also have practical clinical implications. Indeed, the association identified in this study represents the first basis for improving the response on the quality-of-life dimension, which is one of the most important domains given its association with mortality in persons with COPD [56,57]. Assessing the openness to experience trait could help clinicians better target individuals less likely to benefit from the PR intervention on the quality-of-life and thus reinforce prevention for these patients. With this objective in mind, additional research to determine cut-off scores for this trait, to detect the most vulnerable patients, would be highly relevant. Moreover, the differential effectiveness of a PR program according to one's personality emphasizes the importance to tailor non-pharmacological therapy to individual characteristics. In this perspective, future studies should help define which are the most suitable PR modalities and contents according to one's dispositions, including personality traits.

Strengths and methodological considerations

The present study has several strengths that include the investigation of PR effectiveness through both physiological and psychological indicators. Moreover, we analyzed PR effects using two complementary methodological approaches (evolution versus response). Finally, this study is one of the few to propose a composite indicator of PR response, which is more representative of the multiple objectives of this intervention. Some methodological considerations deserve some special attention. First, for the sake of statistical rigor, we chose to lower our significance threshold to 0.01. Nevertheless, results that did not express themselves according to the threshold we imposed may deserve more attention. Replication studies would be relevant to identify which results would be consistent. Moreover, the validity of MCIDs [37] used to categorize responders and non-responders on dyspnea dimensions are questionable since they were not defined after a clinical intervention. However, they were the only MCIDs available and published to date. Finally, due to the lack of composite indicators in the literature, the methodology used to categorize good and poor responders, was defined in an arbitrary manner. Despite this limit, the resulting proportion of responders (62%) and non-responders (38%) is consistent with previous studies that reported a response rate of over 50% [5,6,8,10]. Furthermore, findings pointing to good responders having lower affective dimension scores compared with poor responders is in line with previous studies that found a poorer health status at baseline in good responders, including dyspnea [7,58].

Conclusion

To sum up, identifying the determinants of PR effectiveness represents a major human, clinical and economic challenge. The present study shows that investigating personality traits as defined by the Five-Factor Model constitutes an interesting perspective to understand the heterogeneity observed in PR response. Specifically, our results indicate that high openness is associated with a lower likelihood of responding to PR on health-related quality of life. Thus, this study highlights the existence of new psychological factors that could be taken into account to design new strategies for individualized care pathways. However, additional research is needed to implement these findings in clinical practice.

AUTHOR CONTRIBUTIONS

P.C, N.H, V.M and F.A conceived and designed research. P.C performed experiments and analyzed data. P.C, N.H, V.M and F.A interpreted results of experiments. P.C prepared tables and drafted manuscript. N.H, F.A and V.M edited and revised manuscript. P.C, N.H, V.M and F.A approved final version of manuscript.

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DISCLOSURE

The authors declare no conflicts of interest financial or otherwise. The results of this study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation.

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