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ORIGINAL RESEARCH

Long-Term Effectiveness of a Home-Based Pulmonary Rehabilitation in Older People with Chronic Obstructive Pulmonary Disease: A Retrospective Study

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Sarah Gephine[1,2]
Olivier Le Rouzic[3,4]
François Machuron[5]
Benoit Wallaert[3]
Cécile Chenivesse[3,4]
Didier Saey[2]
François Maltais[2]
Patrick Mucci[1]
Jean-Marie Grosbois[6]

[1]Univ. Lille, Univ. Artois, Univ. Littoral Côte d'Opale, ULR 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, Lille F-59000, France; [2]Institut Universitaire de Cardiologie et de Pneumologie de Québec, Université Laval, Québec, Canada; [3]CHU Lille, Service de Pneumologie et Immuno-Allergologie, Centre de Référence Constitutif des Maladies Pulmonaires Rares, Lille F-59000, France; [4]Univ. Lille, Lille F-59000, France; [5]Department of Biostatistics, Univ. Lille, CHU Lille, EA 2694 - Santé Publique: Épidémiologie et Qualité des Soins, Lille F-59000, France; [6]FormAction Santé, Pérenchies, France

Background: Long-term effectiveness of pulmonary rehabilitation (PR) is still uncertain in older people with severe chronic obstructive pulmonary disease (COPD). The objective was to compare the effects of home-based PR in people with COPD above and below the age of 70 years.

Methods: In this retrospective study, 480 people with COPD were recruited and divided into those ≤70 (n=341) and those >70 years of age (n=139). All participants underwent an 8 weeks of home-based PR, consisting of a weekly supervised 90-minute home session. Six-minute stepper test (6MST), timed-up and go test (TUG), Hospital Anxiety and Depression Scale, and Visual Simplified Respiratory Questionnaire (VSRQ) were assessed at baseline (M0), at 2 (M2), 8 (M8), 14 (M14) months after baseline.

Results: The older group was described by fewer current smokers ($p < 0.001$), more long-term oxygen therapy use ($p = 0.024$), higher prevalence of comorbidities ($p<0.001$), lower 6MST score and higher TUG score ($p<0.001$), compared to the younger group. Both groups improved every outcome at M2 compared to baseline. At M2, 88% of people ≤70 years of age and 79% of those above 70 were considered as responders in at least one evaluated parameter ($p = 0.013$). Both groups maintained the benefits at M14, except for the VSRQ score and the number of responders to this outcome in the older group.

Conclusion: Regardless of the age, personalized home-based PR was effective for people with COPD in the short term. Above 70 years, an ageing effect appeared on the long-term effectiveness of quality of life benefit.

Keywords: chronic obstructive pulmonary disease, exercise tolerance, pulmonary rehabilitation, quality of life, older age

Introduction

Pulmonary rehabilitation (PR) including education, motivational support, and physical activity training, is the main non-pharmacological component of chronic obstructive pulmonary disease (COPD) treatment.[1] The positive effects of PR on dyspnoea, fatigue, health-related quality of life, emotional function and exercise capacity have been repeatedly confirmed.[2–4] Despite the positive effects, fewer than 10% of people with COPD engage in traditional outpatient PR.[5] Trying to increase the participation rate, some facilities offer personalized home-based PR. This therapeutic model seems especially appropriate for the more severe patients, for

Correspondence: Jean-Marie Grosbois
FormAction Santé, Pérenchies, Zone d'Activité du Bois, Rue de Pietralunga, Pérenchies, F-59840, France
Email jmgrosbois@formactionsante.com

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whom travel to a facility-based programme, social deprivation, long-term oxygen therapy (LTOT), mobility limitation and frailty could constitute barriers to engage in outpatient PR.[6,7] In COPD, home-based PR is feasible and conducts the same benefits in the short and long term, as the inpatient or outpatient programme.[8–10]

The prevalence of COPD is increasing in people over age groups.[11] In the current context of an ageing population associated with concerns about COPD-related health costs, it seems necessary to tailored PR programmes to older people with a higher risk of severe COPD and comorbidities. Indeed, it is common for older people to suffer from heart diseases, undernutrition, alterations in cognitive function, poor functional capacity and decreased muscle function and exercise capacity.[12,13] Because of its physiological and functional effects, PR has sometimes been considered inappropriate for older people with COPD, especially for whom at risk of chronic respiratory failure.[14,15] Few retrospective studies have evaluated the effectiveness of PR in people with COPD over the age of 70, in comparison to their younger counterparts.[16–18] However, none of these reported on the efficacy of home-based PR and on the long-term benefits in people with COPD above 70. Moreover, the features of home-based settings may facilitate the attendance of older people with COPD requiring LTOT[10] but the effects of age combined with respiratory aid equipment on PR were never reported. The aim of this study was to determine whether being older than 70 years impacts the short- and long-term effects of a home-based PR on exercise tolerance, functional capacity and health related to the quality of life in people with COPD.

Methods

Study Design and Participants

This was a large observational study conducted in a private company offering home-based PR for people with the chronic respiratory disease living in the north of France, from January 2010 to June 2017, with retrospective data analysis performed in 2019. Participants were referred to the home-based PR by their pulmonologist who diagnosed COPD according to the Global initiative for chronic obstructive lung disease (GOLD) classification system and validated that the participants were absent of cardiovascular contraindications to exercise training. From 2010 to 2017, more than one hundred pulmonologists referred their patients to the programme. Participants were excluded from the retrospective analysis if they had dementia or poorly controlled psychiatric illness, neurological sequelae, or bone and joint diseases preventing physical activity, or if they refused during the initial visit to participate in the PR. Participants were divided into two groups: one group included individuals aged ≤70 years, and the other one, people >70 years. The cut-off of 70 years to define the older group was chosen in accordance with the World Health Organization report on ageing and health.[19] The study was performed in accordance with the observational research protocol evaluation committee of the French Language Society of Pulmonology (CEPRO 2017–007), who approved the retrospective analysis. All participants signed a written informed consent prior to the start of the programme which included their approval to use the collected data for research purposes.

Home-Based PR Programme

All participants received a home-based PR programme tailored to each patient's individual needs as previously described.[20,21] Briefly, it consisted of a weekly supervised 90-minute home session, for 8 weeks. The rehabilitation team was composed of one pulmonologist, two nurses, one dietician, one physiotherapist, two adapted physical activity instructors and one sociomedical beautician. The healthcare team received the same standardized therapeutic education training. The programme included an initial educational needs assessment, endurance physical exercise training, specific daily living functional task training, strengthening and balance exercises, lower limb electrostimulation, therapeutic education, psychosocial support, and motivational communication.[22] Each participant received a cycle ergometer (Domyos VM 200, Decathlon, Villeneuve-d'Ascq, France) during the 8-week programme to perform endurance training. It was initially performed by 10-minute sequences (or sometimes shorter if the participant was unable to perform it), at least 5 days per week, by trying to achieve 30–45 minutes of exercise, in one or several sessions, per day. Exercise intensity was progressively adjusted to dyspnoea symptoms in order to maintain a score between 3 and 5 on the Borg 0–10 scale. For the most unconditioned participants, for whom the initial 6-minute stepper test score was <150 strokes, the training started with two 30-minute sessions daily of quadriceps electrostimulation, 5 times a week.[23,24]

Apart from the weekly visit of the team member who supervised the sessions, participants were expected to perform, on their own, personalized daily physical activities and endurance exercises training the rest of the week and during the follow-up period, during which there was no visit by the PR team apart from those mandated to complete the evaluation at 8 and 14 months after PR. Patients and team members were instructed to announce all adverse events including study withdrawal for any reasons, hospitalization or death during PR and the 12-month follow-up.

Assessments

Patients were evaluated at home at the beginning (M0), at the end of the 8-week PR programme (M2), and at 8 (M8) and 14 months (M14) to conclude a full year of follow-up post PR. As previously described, the 6-minute stepper test (6MST)[25] and the timed up-and-go test (TUG)[10] were used to evaluate exercise tolerance and functional capacity, respectively. The psychological status and the health-related quality of life were assessed with the Hospital Anxiety and Depression (HAD) scale,[26] and the Visual Simplified Respiratory Questionnaire (VSRQ),[27] respectively.

In COPD, the minimal clinically important difference (MCID) of the 6MST, the TUG, the HAD-anxiety and -depression scores and the VSRQ, is considered to be a change of 40 strokes,[28] 1.5 seconds,[29] 1.5 units[30] and 3.4 points,[27] respectively. Individuals were defined as a PR responder if they reached the MCID of at least one of the outcomes (6MST, TUG, anxiety, depression and VSRQ). Finally, the burden of comorbidity was assessed using the Charlson Index[31] calculated without adjusting for age and without including COPD in the individual's score, as previously suggested.[32]

Statistical Analysis

Statistical analysis was performed using SAS V9.4 (SAS Institute, Cary NC, USA) and the significance threshold was considered at 0.05. Variables were expressed as mean ± standard deviation or as frequencies and percentage, and were tested for normality. Between groups comparison for baseline variables were performed using Chi-squared test and *t*-test. Linear random effects mixed model was used to evaluate the changes in study outcomes over time (M2, M8, M14), considering baseline value as a covariate. Residual analyses were used to validate the models. In the case of the non-normality of residuals, the data were log-transformed. All analyses were adjusted for confounding factors (age, LTOT, heart rhythm disorders, hypertension, diabetes, high cholesterol, coronary heart disease, smoking status, weight and height).

Results

From January 2010 to June 2017, 509 people with COPD were referred to the home-based PR. Amongst them, 15 people refused to be contacted by the private company and another 14 participants refused to start the programme after the initial visit (Figure 1). The majority of the 480 participants included in the retrospective analysis were males, aged 64 ± 11 years and had severe COPD with cardiac comorbidity (Table 1). Over two thirds of the total group used LTOT. Among the 480 participants, 341 (71%) were ≤70 years old (mean age 59 ± 8 years), and 139 (29%) were assigned in the older group (mean age 77 ± 5 years). The older group was characterized by fewer current smokers ($p < 0.001$), higher predicted FEV_1 ($p = 0.019$), higher prevalence of comorbidities ($p < 0.001$), and more users of LTOT ($p = 0.024$) compared to the younger group (Table 1).

At baseline, the older group had lower HAD total score ($p = 0.038$), anxiety score ($p = 0.001$), and 6MST performance, and higher TUG score ($p<0.001$) than the younger group (Table 2). Apart from the HAD score, these differences remained significant after adjustment for baseline cofounding factors. Depression and VSRQ scores were comparable between the two groups.

Withdrawals

No adverse events related to PR were observed. At M14, 97 (28%) and 47 (34%) of people in the younger and older group, respectively, had withdrawn from the study ($p=0.203$) (Figure 1). A total of 42 patients died during the study: 27 (8%) in the younger group and 15 (11%) in the older group ($p=0.313$) (Figure 1).

Outcomes Evolution and Responders Analysis

Short- and long-term effects of PR according to age are shown in Table 3 and Figure 2. The younger group showed improvements in all outcomes between baseline and M2, M8 and M14 ($p<0.001$). The older group improved all outcomes only between baseline and M2 ($p<0.001$). In this group of patients, only HAD total score, anxiety and depression scores remained improved thereafter. TUG and 6MST score were not different at M8 compared to the baseline ($p= 0.399$ and $p=0.179$, respectively), but reached again the significant level at M14. Comparison showed similar time courses for all

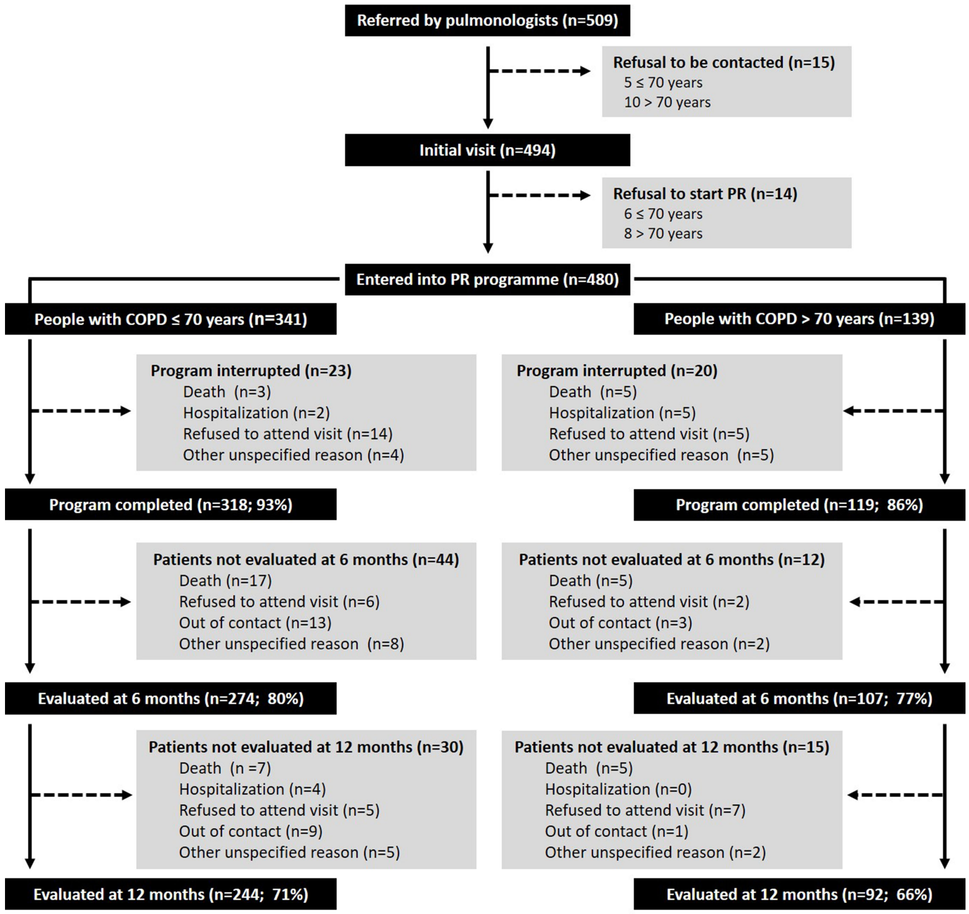

Figure 1 Flow chart of the long-term follow-up participants according to age.

outcomes between younger and older individuals, even after being adjusted for baseline value and confounding factors.

The proportion of responders according to age is presented in Figure 3 and in Table S1. At M2, 88% of people under 70 years were considered as responders in at least one outcome compared to 79% of people aged >70 ($p = 0.013$). At M8 (72% versus 65%, $p = 0.11$), and M14 (66% versus 57%, $p = 0.068$), the proportion of responders in comparison to M2, decreased similarly in both groups. A similar percentage of responders between the two groups was observed at M2, M8 and M14, except for the VSRQ score where the younger group showed more responders (M2: 67 versus 55%, $p = 0.05$; M8: 64% versus 44% and M14: 62% versus 39%, $p<0.01$) compared to the older group.

Discussion

The main findings of this real-life study are that people with COPD requiring long-term oxygen therapy or non-invasive ventilation involving in home-based PR after the age of 70 as compared to their younger counterparts: i) similarly benefited from home PR, with the exception of health-related quality of life for which initial improvement was lost at the long term in the older ones; ii) showed similar proportions of long-term responders, up to 1 year after the programme, with the exception of health-related quality of life for which there were fewer long-term responders in the older ones; iii) showed similar prevalence of deaths and withdrawals from PR.

The older group was characterized by a smaller proportion of active smokers, had a larger proportion of individuals on LTOT, and presented more comorbidities compared to the younger group. After adjustment for these variables, people in the older group had lower anxiety scores and lower exercise tolerance and functional capacity, defined as the individual's maximal potential to realize a functional activity in a standardized environment,[33] compared to the younger group. COPD is frequently associated with comorbidities like cardiovascular and metabolic disorders,

Table 1 Baseline Characteristics of Participants

Characteristics	Total Group (n = 480)	≤ 70 Year (n = 341)	> 70 Years (n=139)	p-value
Age, years	64 ± 11	59 ± 8	77 ± 5	<0.001
Female, nb (%)	170 (35)	127 (37)	43 (31)	0.19
BMI, kg/m^2	27 ± 8	27 ± 8	26 ± 7	0.35
Current smokers, nb (%)	84 (17)	72 (21)	12 (9)	<0.001
LTOT, nb (%)	319 (66)	216 (63)	103 (74)	0.024
NIV, nb (%)	163 (34)	125 (37)	38 (27)	0.051
CPAP, nb (%)	41 (8)	27 (8)	14 (10)	0.445
No equipment, nb (%)	113 (23)	89 (26)	24 (17)	0.039
Pulmonary function				
FEV_1, % of predicted	39 ± 17	38 ± 17	41 ± 15	0.019
FEV_1/FVC, %	51 ± 14	51 ± 14	54 ± 13	0.089
GOLD stade, nb (%)				0.092
1	4 (1)	3 (1)	1 (1)	
2	101 (21)	72 (21)	29 (21)	
3	201 (45)	145 (42)	56 (40)	
4	174 (36)	121 (35)	53 (38)	
Comorbidities				
Asthma, nb (%)	55 (11)	41 (12)	14 (10)	0.54
Sleep apnea, nb (%)	123 (26)	87 (25)	36 (26)	0.61
Systemic hypertension, nb (%)	193 (41)	114 (33)	79 (57)	<0.001
Cardiovascular disease, nb (%)	275 (57)	160 (47)	115 (83)	<0.001
Diabetes, nb (%)	102 (21)	60 (18)	42 (30)	0.010
Cholesterol, nb (%)	104 (22)	64 (19)	39 (28)	0.031
Cancer, nb (%)	74 (15)	45 (13)	29 (21)	0.024
Rheumatologic disease, nb (%)	144 (30)	93 (27)	51 (37)	0.012

Note: Data are presented as n (%) or mean ± SD.
Abbreviations: BMI, body mass index; LTOT, long-term oxygen therapy; NIV, non-invasive ventilation; CPAP, continuous positive airway pressure; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; cardiovascular disease, included heart rhythm disorders, hypertension, heart failure and coronary heart disease; cancer, included lung, digestive, breast and prostate cancer; rheumatologic disease, included osteoarthritis and osteoporosis.

depression, osteoporosis, lung cancer, or muscle dysfunction whose prevalence is often accentuated by aging.[34] To which extent these comorbidities mitigate the success of PR is controversial.[35,36] Our results are in line with those demonstrating that a higher prevalence of comorbidities in older people with severe COPD does not impact the completion and effectiveness of PR, at least in the short term. Education and

Table 2 Assessments at Baseline

	Total Group (n = 476)	≤ 70 Year (n = 338)	> 70 Years (n=138)	p-value	[a]Adjusted p value
HAD, score					
Total	17.8 ± 7.7	18.3 ± 7.7	16.6 ± 7.5	0.038	0.254
Depression	8.0 ± 4.2	8.0 ± 4.3	8.0 ± 4.2	0.932	0.664
Anxiety	9.9 ± 4.6	10.3 ± 4.6	8.7 ± 4.5	0.001	0.016
VSRQ, score	31.2 ± 15.3	30.7 ± 15.3	32.2 ± 15.4	0.372	0.506
6MST, strokes	311 ± 153	339 ± 153	226 ± 118	<0.001	<0.001
TUG, seconds	11.3 ± 6.8	9.9 ± 6.2	14.6 ± 7.2	<0.001	<0.001

Notes: Data are presented as mean ± SD. [a]Adjusted for age, oxygen therapy, heart rhythm disorders, hypertension, diabetes, high cholesterol, coronary heart disease, smoking status, weight and height.
Abbreviations: HAD, Hospital Anxiety and Depression Scale; VSRQ, Visual Simplified Respiratory Questionnaire; 6MST, 6-minute stepper test; TUG, timed up-and-go test.

Table 3 Changes of the Outcomes in the Short and Long Term After PR According to Age

HAD, Score	≤ 70 Year			> 70 Years		
	M2.	M8.	M14.	M2.	M8.	M14.
Total	15.0 ± 7.3**	13.9 ± 7.6**	14.3 ± 7.7**	13.6 ± 7.1**	12.7 ± 7.2**	13.2 ± 7.6**
Depression	6.3 ± 4.2**	5.7 ± 4.1*	5.8 ± 4.4*	6.0 ± 3.9*	5.9 ± 3.7**	6.2 ± 4.2*
Anxiety	8.8 ± 4.1*	8.3 ± 4.5**	8.4 ± 4.6*	7.6 ± 4.1*	6.9 ± 4.5**	7.1 ± 4.5*
VSRQ, score	39.7 ± 16.1**	40.5 ± 16.9**	39.9 ± 16.6**	37.8 ± 15.8**	35.7 ± 14.3*	34.8 ± 13.4
6MST, strokes	406 ± 165**	407 ± 182**	432 ± 186**	301 ± 135**	265 ± 150	325 ± 140**
TUG, seconds	8.6 ± 6.3*	8.9 ± 4.8*	8.4 ± 4.2*	13.3 ± 8.2*	13.4 ± 6.7	12.6 ± 5.5*

Notes: Data are presented as mean ± SD. *p<0.01 and **p<0.001 outcomes significantly improved by comparison with baseline. Data lost across the time were taking into account by the linear random effects mixed model used.
Abbreviations: HAD, Hospital Anxiety and Depression Scale; VSRQ, Visual Simplified Respiratory Questionnaire; 6MST, 6-minute stepper test; TUG, timed up-and-go test.

self-management sessions are important to induce a change in appropriate behaviours during PR.[37] Therapeutic education about comorbidities and their treatment played a leading role during our 8-week home-based programme.

People with COPD benefit to a similar extent from an inpatient, outpatient or home-based PR,[38] regardless of the severity of the disease,[10] the socioeconomic status,[21] or gender; these benefits also persist on the long-term follow-up.[20] Because of the physiological effects of ageing and comorbidities, it has been suggested that PR may not be adapted to older patients.[14,39] Our results demonstrated that regardless of the age, one weekly individualized home PR session associated with self-monitored home exercises during 8-week induced short-term benefits on exercise tolerance, functional capacity, health-related quality of life, anxiety and depression. These results are thus in agreement with previous work also conducted in older people with COPD showing the benefits of 6 to 8 weeks of outpatient PR on all these outcomes.[18,39] The originality of our study was to evaluate the benefits of a home-based PR in people with severe COPD receiving mostly long-term oxygen therapy and/or non-invasive ventilation. Only a few studies have been reported in this specific population,[10,40] but collectively these studies and our highlight that older people with chronic respiratory failure should be considered an appropriate candidate for PR.

We opted to complete all evaluations at home; as a result, we chose the 6MST to evaluate exercise tolerance. In addition to the improvement of the 6MST performance, more than half of our participants were considered as PR responders to the 6MST, in the short and long term. The 6MST baseline score was significantly lower in the older than in the younger group, which is in line with the previous observation of a mean score fewer than 250 strokes in older people with COPD and CRF.[10]

The concomitant occurrence of ageing, LTOT and cardiac comorbidities promote the adoption of a sedentary lifestyle, sarcopenia and exercise intolerance in the older people. Moreover, COPD and LTOT are risk factors for fall.[41] As such, because it includes various functional components essential for independent living, the TUG test is recommended as a routine screening evaluation for falls and mobility in geriatric populations[42] and a cut-off value of 11 seconds is suggested to detect people at risk of falling in COPD.[43] With a TUG baseline score of 15 seconds, the older group was significantly at risk of falling. Despite these baseline characteristics, the older group improved the 6MST and the TUG to the same extent as the younger group. These favorable results could be related to the nature of the home-based programme which adapted individualized daily physical activities for the most unconditioned people using lower limb electrostimulation, shorter endurance physical exercise, light muscle strengthening and balance. Together with the functional improvements, a large proportion of participants in both groups achieved clinically important improvements in VSQR (60%) and HAD (40%) scores after the home PR, compared to less than 30% in the literature.[18]

The best strategy to maintain the initial effects of PR on a longer-term basis is still uncertain.[44,45] Katsura et al showed that older people could maintain PR benefits 1 year after an inpatient programme composed of individual daily sessions for 2 weeks, but the study sample size was small and the exercise tolerance improvement was low (<10%).[46]

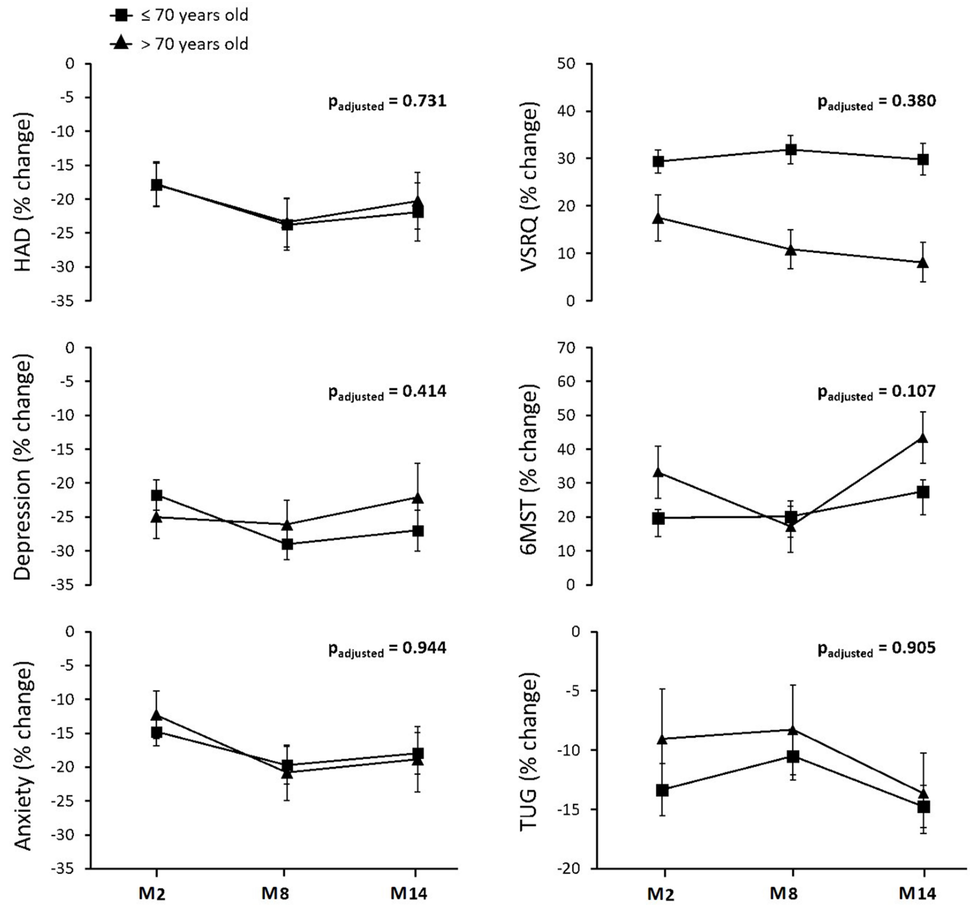

Figure 2 Changes in exercise tolerance, functional capacity, quality of life, anxiety, and depression according to age group. Mean percentage of changes in HAD total score, depression and anxiety subscores, VSRQ, 6MST and TUG at M2, M8, and M14 (2, 6, and 12 months after the PR) for participants ≤ 70 year (closed square) and > 70 years (closed triangle). Data are presented as the mean ± SEM. Statistical analysis were adjusted for baseline value of age, long-term oxygen therapy, heart rhythm disorders, hypertension, diabetes, high cholesterol, coronary heart disease, smoking status, weight and height. $P_{adjusted}$ is the $P_{interaction}$ for the interaction between time and group (ie, <0.05 indicates a significant difference in the change in variable with time compared between the two groups).

Long-term follow-up following PR is often poorly documented, with an average of less than 50% of participants evaluated 1 year after the PR.[47] In the present study, more than two thirds of the participants were evaluated at 1 year, regardless of the age, suggesting that older age does not specifically impact PR attendance. Eight weeks of home-based intervention follows by one visit 6 months after (M8), seems to facilitate the adherence and maintaining PR benefits up to 1 year after the programme. However, the medium-term maintenance of exercise tolerance and functional capacity and the long-term maintenance of the health-related quality of life was more challenging in the older group. It is possible that offering a closer follow-up (visits at 3, 6, 9 and 12 months after PR, for example) would help older people to better maintain the benefits of PR.

The monocentric, observational, non-randomized, and retrospective nature of this study may limit the generalizability of the results. However, data were collected systematically and consistently as an integral part of the home-based PR including a large number of participants in a "real life" setting. The programme was funded by oxygen companies allowing for even the most in-need people to benefit. Also, the intervention was conducted according to a well-defined protocol and always by the same trained team. By improving external validity and establishment in usual care, real-life studies such as the present one are useful to complement the results of traditional randomized controlled trial.[48]

In conclusion, the present retrospective study demonstrated that, although being older than 70 years is associated with reduced exercise tolerance and functional capacity and higher prevalence of comorbidities and long-term oxygen therapy use, this does not prevent people with

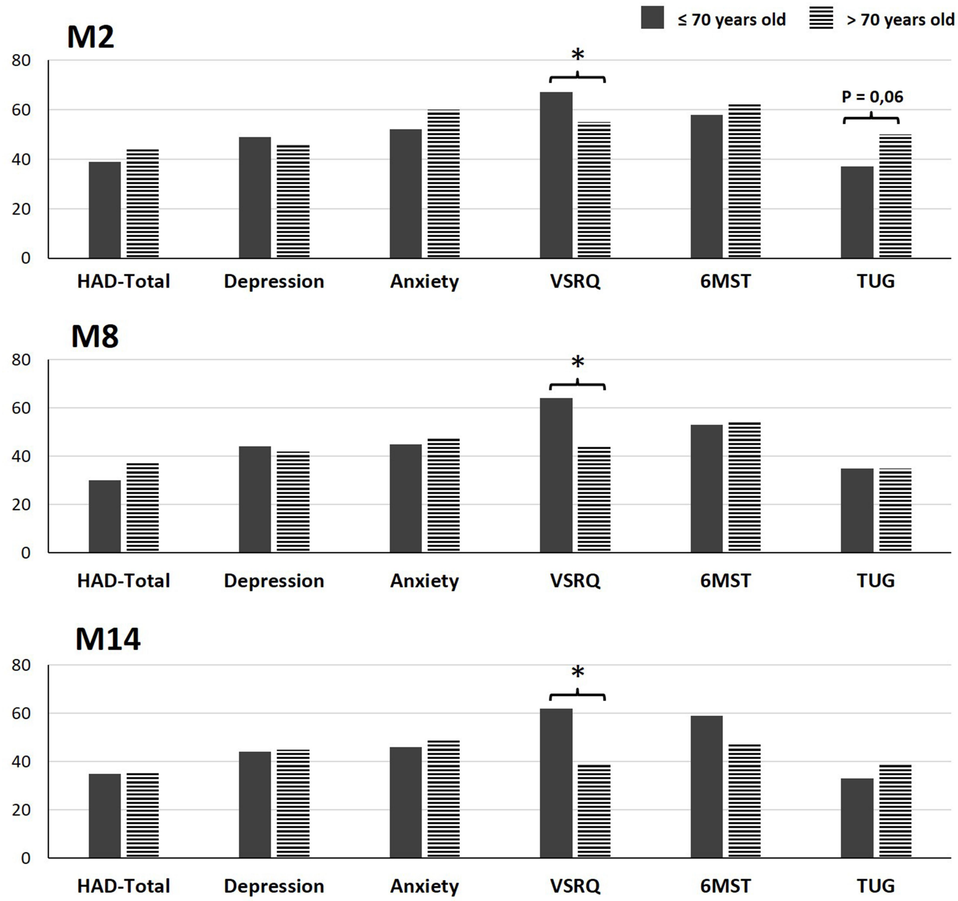

Figure 3 Percentage of home-based PR responders according to age. Data are presented as the percentage of people who responded to PR, with response defined as a change ≥ MCID from baseline to M2, M8 and M14 in each outcomes. *difference between group, M2: p = 0.05; M8: p<0.005; M14: p<0.005.

COPD from deriving short- and long-term benefits from home-based PR.

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Disclosure

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