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Original Research

Home-based pulmonary rehabilitation for adults with severe asthma exposed to psychosocial chronic stressors

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ABSTRACT

Objective: To evaluate the effects of a home-based pulmonary rehabilitation (PR) programme on hyperventilation symptoms, anxiety and depressive symptoms, general fatigue, health-related quality of life (HRQoL) and exercise capacity in adults with severe asthma who have been exposed to psychosocial chronic stressors.
Methods: Data on 111 non-selected consecutive adults with severe asthma who enrolled in an 8-week home-based PR programme (weekly supervised 90-min session) was retrospectively analysed. Chronic stressors included physical, sexual and psychological violence and/or a traumatic experience related to an intensive care unit stay. Hyperventilation symptoms (Nijmegen questionnaire), Hospital Anxiety and Depression Scale, Fatigue Assessment Scale, COPD Assessment Test, Six-Minute Stepper Test and Timed-Up and Go test were assessed at baseline and after PR.
Results: At baseline, participants who have been exposed to chronic stressors (n = 48, 43.2%) were younger, more often female, more often treated for anxiety and depressive disorders, and had a higher score for anxiety symptoms, hyperventilation symptoms and a poorer HRQoL, compared to those who had not been exposed to chronic stressors ($p < 0.05$). All the study assessments were statistically improved after PR for both groups ($p < 0.001$). Anxiety and depressive symptoms, fatigue and health-related quality of life questionnaires were also clinically improved based on the minimal clinically important difference.
Conclusion: A large proportion of adults with severe asthma, mainly women, have been exposed to chronic stressors at the time of starting a PR programme, resulting in higher anxiety symptoms and hyperventilation symptoms. However, it did not prevent these individuals from benefiting from PR.

1. Introduction

Asthma is a heterogeneous disease that affects about 270 million individuals globally [1]. People with asthma experience respiratory symptoms that vary over time and in intensity, such as wheezing, dyspnea, chest tightness and cough, affecting health related quality of life (HRQoL) and exercise capacity [2,3]. Despite a high level of pharmaceutical treatment control, these symptoms may be experienced daily for 3%–10% of individuals suffering from severe asthma [4], which may be life-threatening, and increase the prevalence of anxiety and depressive symptoms [5,6]. People with uncontrolled severe asthma have a markedly higher frequency of comorbidities, medication use and number of yearly exacerbations and hospitalisations increasing the risk of mortality and asthma-related health costs [7,8].

Psychosocial determinants, such as post-traumatic stress disorder, physical, psychological and sexual violence are known to increase the prevalence of asthma and are predictors of worsened asthma control and morbidity, in both children and adults [9–17]. Large international cohorts have reported that experiencing sexual violence was associated with 1.4–1.73 times increased odds of self-reported asthma, even after

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accounting for potential confounders (age, education, ethnicity, household income or health insurance) [12,17]. Experiencing intimate partner violence has been positively associated with asthma exacerbation, uncontrolled asthma, nocturnal awakenings and daytime symptoms [13]. Suffering from post-traumatic stress disorder also increased risk for airflow limitation and for asthma-related symptoms [14]. Although the mechanisms are not well known, it was suggested that chronic stress leads to a pro-inflammatory state which may increase asthma prevalence and severity [13].

Pulmonary rehabilitation (PR) is an evidence-based, transdisciplinary intervention, including education, psychosocial and motivational support, and physical activity training, that is highly effective for improving exercise tolerance and HRQoL in people with chronic respiratory disease [18,19]. PR effectiveness was mostly reported in patients with chronic obstructive pulmonary disease (COPD) [18–20], but there is growing evidence of its positive impact in individuals with asthma, irrespective of the severity of the disease [21–26]. PR seems to be particularly important in individuals with severe asthma [27,28], in whom additional psychosocial factors often contribute to asthma severity and control [16]. However, the proportion of adults with severe asthma who have been exposed to chronic stressors at the time of starting PR and the effects of the intervention on asthma clinical outcomes, have not been reported. It is urgent to identify this specific population enrolling into PR programme to provide the best personalized care [29].

The objective was twofold: *i*) to evaluate the proportion of adults with severe asthma who have been exposed to chronic stressors (physical, sexual and psychological violence or a traumatic experience related to an intensive care unit stay), when starting a home-based PR programme and describe their clinical portrait compared to those who has not been exposed to chronic stressors; *ii*) to evaluate the effects of PR on hyperventilation symptoms, anxiety and depressive symptoms, general fatigue, health-related quality of life, and exercise capacity in adults with severe asthma.

2. Methods

2.1. Study design and participants

This was a retrospective study conducted on prospectively non-selected and consecutive collected data, from June 2017 to September 2022. Eligible individuals, aged 18 years or above, were referred to the home-based PR programme by their respiratory specialist who was responsible for providing the clinical assessment and certifying the presence of severe asthma according to the Global Initiative for Asthma (GINA) classification (step 4–5) [30]. Participants fulfilling the criteria of asthma-chronic obstructive pulmonary disease overlap (ACO) were not excluded from the cohort to be representative of the real-life patients in clinic. Participants were divided into two groups based on their exposure to chronic stressors. An individual was classified in the chronic stressors group when he/she freely mentioned during one of the 8-week PR session, having experienced (during childhood or adulthood) or currently experiencing one of the following: sexual, physical and/or psychological violence, or a post-traumatic stress disorder related to an intensive care unit stay for asthma exacerbation. No specific questionnaire was used to assess chronic stressors exposure. However, PR sessions were one-to-one (could also include the caregiver) and team members received training in psycho-social and motivational approaches, both helping the patient to open up about their traumatic experience.

The study was approved by the observational research protocol evaluation committee of the *Société de pneumologie de langue Française* (CEPRO, number 2021–054). 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.

2.2. Home-based PR programme

All participants performed an 8-week home-based PR programme, consisting of a weekly supervised 90-min home session, during which education and self-management strategies and physical training were implemented as previously described [31]. Prior to starting the programme, an evaluation of the patient's needs and expectations was performed for designing a personalized intervention. This was done through a collaborative process between the PR team, the participant and his/her caregiver (if present). The healthcare team received the same standardized therapeutic education training from a licensed instructor. Apart from the weekly visit of the team member who supervised the sessions, participants were expected to perform, on their own, personalized physical training (at least 5 sessions/week) and self-management plan the rest of the week.

Education and self-management interventions were adapted to respond to individual's needs, barriers and personal goals. The core education topics included pathophysiology of asthma and comorbidities, medication and its use, prevention and recognition of exacerbations and allergic factors, physical exercise, breathing strategies, stress management and emotional responses related to the disease. According to individual needs, other interventions could be added: nutritional counselling, smoking cessation strategies, airway clearance techniques, relaxation techniques such as yoga, cardiac coherence (using biofeedback during breathing technique to control heart rate variability) [32], mindfulness meditation, and hypnosis.

Each participant received a cycle ergometer (Domyos 120, Decathlon, Villeneuve-d'Ascq, France) and/or a stepper (Go Sport, Grenoble, France), and other muscle strengthening equipment such as dumbbells, elastic bands, swissball or foam balls. Regarding the cardiorespiratory training, the goal was to achieve a total of 30–45 min of daily exercise, (performed by 10-min sequences or shorter according to their respective physical capacity) at least 5 sessions/week. Exercise intensity was progressively adjusted to reach a dyspnea score between 3 and 4 on the modified Borg 0–10 scale or to reach a perceived exertion score between 11 and 13 on the Borg 6–20 scale [33]. Detailed about the physical training can be found elsewhere [34].

2.3. Assessments

Lung function, assessed by spirometry according to standard guidelines (post bronchodilator) [35], medication and comorbidity data were collected from the individual's medical record provided by the respiratory specialist. Epices multidimensional questionnaire was used to assess social deprivation on a quantitative and continuous scale ranging from 0 (no deprivation) to 100 (maximum deprivation). A cut-off score of >30.17 suggests social deprivation [36]. Participants were entirely evaluated at home at the beginning (M0) and at the end of PR (two months later, M2).

The following self-rating questionnaires were given to the participants at the first home diagnostic visit and at the penultimate visit. Participants were instructed to complete the questionnaires on the day before the first assessment visit (M0) and on the day before the last assessment visit (M2). The questionnaires' order completion was not controlled.

The Nijmegen questionnaire was used to assess hyperventilation symptoms (16 items: evaluates shortness of breath, peripheral tetany and central tetany) [37]. It is a five-point ordinal with a total score ranging from 0 to 64, and a cut-off score of ≥ 23 suggests the presence of a hyperventilation syndrome [37].

The Hospital Anxiety and Depression (HAD) scale (14 items: seven each for anxiety and depression with minimum and maximum subscores of 0 and 21; lower is better) [38], and the Fatigue Assessment Scale (FAS) (10 items: five reflecting physical fatigue and 5 reflecting mental fatigue with a test score ranging from 10 to 50; lower is better) were assessed [39]. An anxiety or depressive symptoms score >11 indicates a

probable clinical diagnosis of anxiety or depression, and a FAS score ≥22 suggests abnormal fatigue [39]. The minimal clinically important difference (MCID) of the HAD and FAS have not been documented in asthma, but is considered to be a change of 1.5 units [40] and 4 points [41], respectively, in patients with other chronic respiratory disease.

The EQ visual analogue scale (EQ VAS) was used as a quantitative measure of general health outcome. This is a vertical visual analogue scale where the endpoints are labelled 'Best imaginable health state (100%)" and "Worst imaginable health state" (0%). The COPD assessment test (CAT) was also used to evaluate the impact of asthma symptoms on daily life activities (8 items with a total test score ranging from 0 to 40, lower is better) [42]. In COPD a change of 2 points was determined as a MCID [43].

The 6-min stepper test (6MST) and the timed-up and go (TUG) test were used to evaluate exercise capacity at home, as previously described [44,45]. The MCID of the 6MST is considered to be a change of 40 steps in COPD [46] and a change of 0.9–1.4 s in TUG performance was identified as clinically important [45]. A cut off of 1 s was selected for the present study.

2.4. Statistical analyses

Statistical analyses were performed using SPSS 28.0 (IBM Corp, Chicago, USA) and significance threshold was considered at 0.05. Quantitative variables are expressed as means (standard deviation, SD) in the case of normal distribution or medians (interquartile range, IQR) otherwise. Categorical variables are expressed as numbers (percentage). Normality of distributions was assessed using histograms and Kolmogorov-Smirnov tests. The missing data were imputed using a regression-switching approach. Estimates obtained in the different imputed data sets were combined using the Rubin's rules.

Baseline characteristics and assessments were compared between participants who had been exposed to a chronic stress and those who had not using Student *t* tests in the case of normal distribution or Mann-Whitney tests otherwise.

As the study assessment variables were not normally distributed, changes between M0 (baseline) and M2 (end of PR) were evaluated using Wilcoxon tests for the total group and Friedman ANOVA when comparing between individuals who have been exposed to a chronic stress and those who had not.

3. Results

3.1. Baseline characteristics

From June 2017 to September 2022, 127 people with asthma were enrolled into PR. Among them, 16 participants did not meet the inclusion criteria of severe asthma (Supplementary material, Table S1) and were retrospectively excluded from the analysis (Fig. 1). The majority of the 111 included participants were females (61.8%), living with a partner (79.3%), overweighed (BMI>25 kg/m^2, 68.5%), had airflow limitation (mean FEV_1, 61.1 ± 21.6% of predicted value, mean FEV_1/FVC, 66.6 ± 16.1), used inhaled corticosteroids (97.3%), and/or oral corticosteroids (52.3%) (Table 1). Almost half of the participants were receiving a treatment with biologicals (42.3%) and 17% had asthma-chronic obstructive pulmonary disease overlap (Table 1).

PR, pulmonary rehabilitation.

Amongst the 111 included participants, 48 (43.2%) had been exposed to chronic stressors. Physical, sexual and psychological violence were the most (26.5%) reported chronic stressors (33.3%, 29.2% and 25%, respectively). For 12.5% of them the violence occurred during childhood. Moreover, 16.7% reported a traumatic experience related to an intensive care unit stay. At baseline, those individuals were younger, more often women, more often treated for anxiety and depressive disorders (Table 1), and had a higher score for anxiety, hyperventilation symptoms and HRQoL compared to those who had not been exposed to chronic stressors (Table 2).

The prevalence of social deprivation according to the Epices score in individuals who have been exposed to chronic stressors and those who had not was 54.2% and 49.2%, respectively ($p = 0.346$). Regarding the socio-professional categories, 22.9% and 19.1% of the individuals had what is considered high-levl professional employment (craftsman, trader, entrepreneurs, company managers, and higher intellectual professions), respectively ($p = 0.612$). The number of unemployed individuals was higher in people who suffered from chronic stressors (20.8% vs 4.8% $p < 0.01$). At baseline, 68.7%, 60.4%, 31.2% and 79.2% of the individuals who have been exposed to chronic stressors had hyperventilation symptoms, anxiety symptoms, depressive symptoms and abnormal fatigue respectively (Fig. 2). The prevalence of hyperventilation symptoms and anxiety symptoms was different between groups ($p < 0.05$).

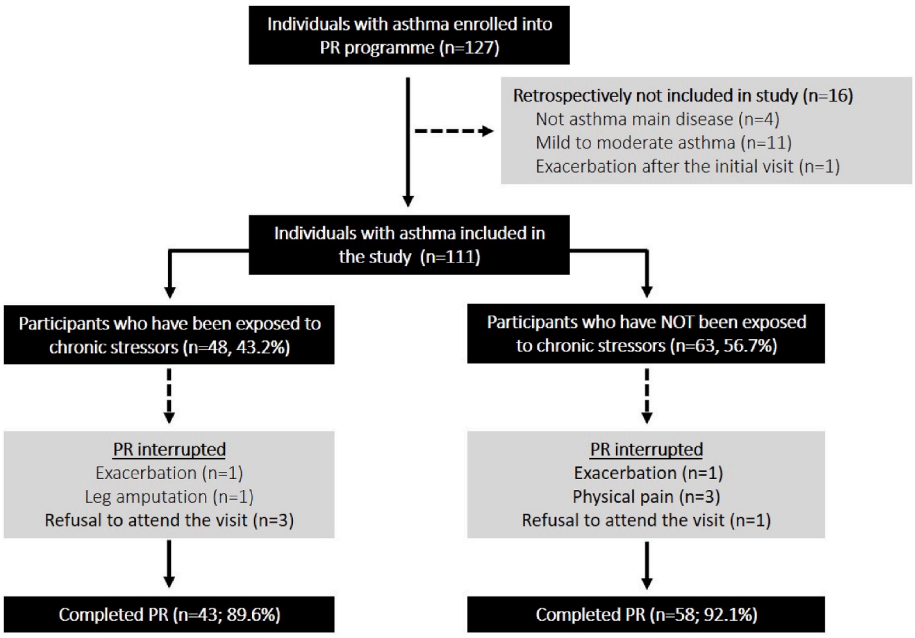

Fig. 1. Flow chart of participants.

Table 1
Baseline characteristics of participants.

Baseline characteristics	Total group (n = 111)	Chronic Stressors (n = 48)	NO chronic stressors (n = 63)	p
Age, years	54.6 ± 12.9	49.7 ± 16.2	58.3 ± 14.5	0.004
Female, n (%)	88 (79.3)	43 (89.6)	45 (71.4)	0.014
BMI, kg/m^2	30.8 ± 9.5	30.4 ± 10.2	31.1 ± 9.8	0.696
Current and former smokers, n (%)	53 (47.7)	23 (47.9)	30 (47.6)	0.845
Single, n (%)	42 (37.8)	21 (43.8)	21 (33.3)	0.266
Epices, score	34.1 ± 16.7	35.9 ± 19.4	32.7 ± 16.8	0.120
Long-acting muscarinic antagonist, n (%)	90 (81.1)	40 (83.3)	50 (79.4)	0.425
ICS + LABA, n (%)	108 (97.3)	47 (97.9)	61 (96.8)	0.727
Oral corticosteroids, n (%)	58 (52.3)	26 (54.2)	32 (50.8)	0.625
Biologicals[a], n (%)	47 (42.3)	23 (47.9)	24 (38.1)	0.308
Leukotriene receptor antagonist, n (%)	28 (25.2)	11 (22.9)	17 (27.0)	0.594
LTOT, n (%)	13 (11.7)	3 (6.3)	10 (15.9)	0.120
NIV, n (%)	13 (11.7)	5 (10.4)	8 (12.7)	0.711
CPAP, n (%)	14 (12.6)	1 (2.1)	13 (20.6)	0.001
FEV_1, % of predicted value	61.1 ± 21.6	62.4 ± 24.7	60.1 ± 26.8	0.646
FVC, % of predicted value	78.6 ± 19.0	79.7 ± 22.5	78.3 ± 23.7	0.776
FEV_1/FVC	66.6 ± 16.1	68.9 ± 19.9	64.4 ± 19.2	0.287
mMRC dyspnea scale	2.62 ± 1.01	2.71 ± 1.0	2.57 ± 1.11	0.321
Comorbidities				
ACO, n (%)	19 (17.1)	8 (16.7)	11 (17.5)	0.523
Obesity hypoventilation syndrome, n (%)	12 (10.8)	6 (12.5)	6 (9.5)	0.415
Obstructive sleep apnea, n (%)	23 (20.7)	5 (10.4)	18 (28.6)	0.267
High blood pressure, n (%)	42 (37.8)	14 (29.2)	28 (44.4)	0.035
Anxiety treated with drug, n (%)	50 (45.0)	27 (56.2)	23 (36.5)	0.027
Depression treated with drug, n (%)	23 (20.7)	19 (39.5)	4 (6.3)	0.001
Osteoarthritis, n (%)	26 (23.4)	7 (14.6)	19 (30.1)	0.028
Gastroesophageal reflux disease, n (%)	45 (40.5)	22 (45.8)	23 (36.5)	0.089

Data are presented as mean ± SD or n (%).
*p < 0.005 between groups.
Abbreviations. BMI, body mass index; ICS, inhaled corticosteroids; LABA, long-acting beta-agonist LTOT, long-term oxygen therapy; NIV, non-invasive ventilation; CPAP, continuous positive airway pressure; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; mMRC, modified Medical Research Council scale; ACO, Asthma and COPD overlap.
[a] Including omalizumab, benralizumab, dupilumab, mepolizumab.

3.2. Changes after pulmonary rehabilitation

All the study assessments were significantly improved after PR for both groups (p < 0.001) (Table 3). Changes in the total group are presented in supplements (Table S2). After PR, 43.7%, 37.5%, 10.4% and 58.3% of the individuals who have been exposed to chronic stressors had hyperventilation symptoms, anxiety and depressive symptoms and abnormal fatigue, respectively. In the other group, the prevalence was 36.5%, 22.2%, 6.3% and 54.0% respectively (Fig. 2). The numbers of individuals reaching the MCID of the clinical assessments are reported in Table 4. Overall, more than a half of the participants had a clinical improvement of the anxiety and depressive symptoms, HRQoL and timed-up and go test, while 95% of the participants clinically improved their fatigue. The clinical improvement of the exercise tolerance was lower especially in individuals who reported chronic stressors. However, these changes were not significantly different between groups.

Table 2
Study assessments at baseline.

Baseline assessments	Total group	Chronic Stressors	NO chronic stressors	p
Nijmegen, score (0–64)	25.1 (16.0–33.0)	28.0 (18.8–36.0)	22.7 (14.0–30.0)	0.028
Anxiety symptoms (0–21)	10.8 (6.0–15.0)	12.3 (8.5–16.0)	9.6 (6.0–13.0)	0.003
Depression symptoms (0–21)	7.8 (4.0–11.0)	8.3 (4.0–13.3)	7.4 (4.0–10.5)	0.369
FAS, score (10–50)	28.9 (22.0–36.0)	30.8 (23.0–39.0)	27.4 (22.0–33.7)	0.041
EQ5D3L-VAS (0–100)	48.9 (40.0–60.0)	46.9 (30.0–65.0)	50.3 (40.0–60.0)	0.241
CAT (0–40)	23.6 (17.0–29.8)	25.1 (19.5–36.0)	22.5 (16.5–27.0)	0.035
6MST, strokes	320 (162–508)	300 (67–508)	336 (200–509)	0.294
TUG, seconds	8.1 (5.5–9.2)	7.8 (5.4–8.4)	8.4 (5.9–9.3)	0.443

Values are presented as mean (interquartile range).
*p < 0.005 between groups.
Abbreviations. FAS, Fatigue Assessment Scale; EQ5D3L- VAS, Visual Analogic Scale; CAT, COPD Assessment Test; 6MST, 6-min stepper test; TUG, Timed-up and go test.

4. Discussion

Despite that negative effects of chronic stressors on asthma severity have been reported, this topic is poorly addressed in clinical care. Yet the novel findings of this real-life study are as follows: *i*) a large proportion (43.2%) of individuals with severe asthma had experienced physical, sexual and/or psychological violence (26.5%), or a traumatic experience related to an intensive care unit stay (16.7%) at the time of starting PR. These individuals were mostly women (90%), who reported a twofold increase in the frequency of anxiety symptoms, an increase of 20% in the frequency of hyperventilation symptoms and a poorer HRQoL compared to those who had not been exposed to chronic stressors; ii) having experienced violence and/or a traumatic experience did not prevent these participants from benefiting from PR by improving hyperventilation symptoms, anxiety and depressive symptoms, general fatigue, HRQoL and exercise capacity to the same extent than individuals who were not exposed to chronic stressors.

The participants with severe asthma (GINA 4–5) were diagnosed by their respiratory specialist before enrolling PR, who was also responsible for prescribing the appropriate medication. Among the 111 participants, 97%, 52% and 42% were using inhaled corticosteroids, oral corticosteroids and biologicals, respectively. Compared to a previous cohort [7], the lower proportion of adults on oral corticosteroids might be explained by the large proportion of patients using biologics. Biologicals may have a positive impact on asthma control and HRQoL. However, none of the participants started biologic treatment during PR and the number of participants using biologicals was not different between groups.

According to our results, the clinical portrait of adults with severe asthma who report having experienced chronic stressors is as follow: younger women [39–60 years], more often unemployed and treated with anxiolytics, who reported hyperventilation and anxiety symptoms and poor HRQoL. The relationships between anxiety/depressive disorders, hyperventilation syndrome and asthma has long been observed in clinical practice and especially in adults with poor asthma control [47,48]. Dafauce et al. demonstrated that 68% and 34% of adults with severe asthma reported anxiety/depressive symptoms and a hyperventilation syndrome, respectively [48]. Experiencing physical, sexual or psychological violence is closely associated with mental health [12,16].

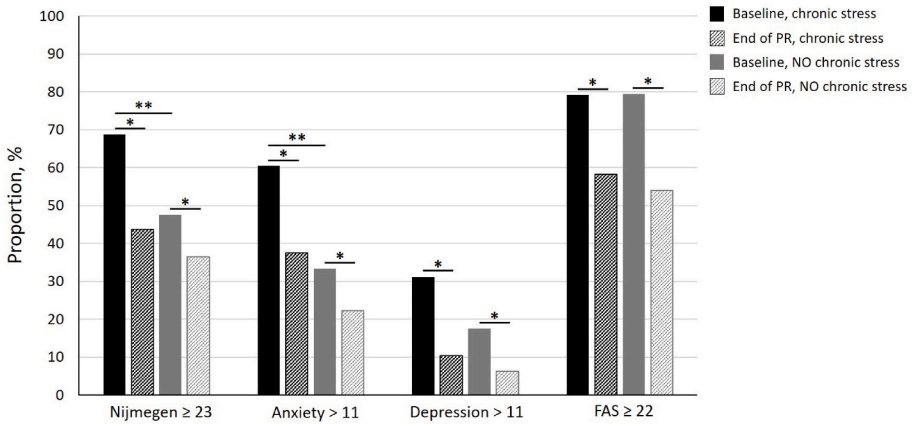

Fig. 2. Changes in proportion of patients with hyperventilation symptoms, anxiety and depression symptoms and abnormal fatigue in individuals who had been exposed to chronic stressors (black bars) and in individuals who had not (grey bars). Results are expressed as percentage of individuals reaching the respective cut-off of each questionnaire.
*$p < 0.05$, baseline vs end of PR
**$p < 0.05$, between groups.

Table 3
Changes in study assessment between end of PR (M2) and baseline (M0) in participants who had been exposed to chronic stressors (A) and in those who had not (B).

Wilcoxon Tests M2-M0 A. Chronic stressors	Negative ranks (N, %)	Positive ranks (N)	Ties (N)	Z score	Asymp. Sig.
Nijmegen[a]	39 (81.2)	9 (18.7)	0 (0.0)	−4.581	<0.001
Anxiety symptoms[a]	33 (68.7)	8 (17.0)	7 (14.6)	−4.095	<0.001
Depression symptoms[a]	35 (72.9)	6 (12.5)	7 (14.6)	−4.717	<0.001
FAS[a]	33 (68.7)	10 (20.8)	5 (10.4)	−4.303	<0.001
EQ5D3L-VAS[b]	7 (14.6)	34 (70.8)	7 (14.6)	−4.752	<0.001
CAT (0–40)[a]	37 (77.1)	9 (18.7)	2 (4.2)	−4.024	<0.001
6MST[b]	14 (29.2)	28 (58.3)	6 (12.5)	−2.226	<0.001
TUG[a]	25 (52.1)	7 (14.6)	16 (33.3)	−3.375	<0.001
B. No chronic stressors	Negative ranks (N)	Positive ranks (N)	Ties (N)	Z score	Asymp. Sig.
Nijmegen[a]	53 (84.1)	8 (12.7)	2 (3.2)	−5.425	<0.001
Anxiety symptoms[a]	41 (65.1)	14 (22.2)	8 (12.7)	−3.902	<0.001
Depression symptoms[a]	49 (77.8)	6 (9.5)	8 (12.7)	−5.489	<0.001
FAS[a]	49 (77.8)	12 (19.0)	2 (3.2)	−5.050	<0.001
EQ5D3L-VAS[b]	11 (17.5)	44 (69.0)	8 (12.7)	−4.814	<0.001
CAT (0–40)[a]	48 (76.2)	11 (17.5)	4 (6.3)	−5.153	<0.001
6MST[b]	15 (23.8)	43 (68.2)	5 (7.9)	−3.097	<0.001
TUG[a]	33 (52.4)	12 (19.0)	18 (28.6)	−2.934	<0.003

Abbreviations. FAS, Fatigue Assessment Scale; EQ5D3L- VAS, Visual Analogic Scale; CAT, COPD assessment test; 6MST, 6-min stepper test; TUG, Timed-up and go test.
[a] A positive change is a diminution of the score.
[b] A positive change is an increase of the score.

Therefore, it was not surprising to find a higher proportion of anxiety symptom (60%) and hyperventilation symptoms (69%) in adults who had experienced chronic stressors ($p < 0.05$). On a clinical perspective, it seems important to inform health professionals that almost half (43.2%) of the patients presenting with these characteristics may struggle with chronic stressors. This result is supported by a recent European survey conducted in more than 40 000 "healthy" women in which the prevalence of intimate partner violence (including physical, sexual and psychological) was 51.7%. Overall, these results highlight the importance of training health professionals caring for individuals with severe asthma to this specific topic.

Table 4
Individuals reaching the minimally clinically important difference of the respective assessments after PR.

MCID responders, n (%)	Chronic stressors	NO chronic stressors
Anxiety symptoms, (−1.5 pts)	26 (54.2)	28 (44.4)
Depression symptoms, (−1.5 pts)	27 (56.2)	35 (55.6)
FAS, (−4 pts)	46 (95.8)	60 (95.2)
CAT (−2 pts)	33 (68.7)	44 (69.8)
6MST, (+40 strokes)	18 (37.5)	29 (46.0)
TUG, (−1 s)	26 (54.2)	38 (60.3)

Abbreviations. FAS, Fatigue Assessment Scale; CAT, COPD assessment test; 6MST, 6-min stepper test; TUG, Timed-up and go test.

The benefits of center or home-based pulmonary rehabilitation on dyspnea, exercise tolerance, and health-related quality of life in patients with moderate to severe COPD are well known [20,49]. Although PR efficacity is less documented in asthma, there is growing evidence of its positive impact on health-related quality of life, exercise tolerance, anxiety and depressive symptoms and disease control in individuals with asthma [21–26]. The ProKAR study conducted in two hundred adults with moderate to severe asthma (GINA 3–4) reported an asthma control test improvement of 4.58 points after a 3-week inpatient PR programme, that was maintained a year after PR [26]. This study also reported a positive effect of PR on asthma inflammation with a decrease to levels within the normal range in the fractional exhaled nitric oxide values [26]. The updated GINA recommendations mentioned that other non-pharmacological interventions such as better medication adherence, smoking cessation, physical activity, healthy diet, avoidance of indoor allergens, breathing exercises and management of emotional stress may be considered to improve asthma control [30]. All of these elements are addressed in PR according to the individuals' needs. Therefore, in line with previous studies [21,22,25,26], we demonstrated that 8-week home-based PR programme was statistically effective in adults with severe asthma for improving anxiety and depressive symptoms, fatigue, HRQoL and exercise tolerance. We firstly reported that PR effectiveness was similar whether the participants have been exposed to a chronic stressor or not.

We firstly reported that PR effectiveness was similar whether the participants have been exposed to a chronic stressor or not. The proportion of participants reaching the MCID of each PR assessments was also similar between groups. The MCIDs used in the study were determined in cohorts of patients with COPD and studies are needed to measure if clinical changes are similar in people with asthma. The proportion of individuals reaching the MCID of the anxiety and depressive symptoms (−1.5 points) and the TUG (−1 s) was similar to that reported in patients with COPD [50]. However, despite a similar

exercise tolerance at baseline (320 ± 162 strokes vs 311 ± 153 strokes, respectively), a smaller proportion of the participants with asthma, and especially those who have experienced chronic stressors, reached the clinical significance of the 6MST compared to the previous study (37.5% vs 60.2%, respectively) [50]. We could assume that hyperventilation syndrome and the fear of asthma attack could have limited the intensity of exercise training in people with asthma. Another explanation would be that, after disclosing their traumatic experience, PR sessions would have been more focus on the psycho-social approach at the expense of exercise training.

Previous studies have suggested that cognitive behavioral therapy sessions combined with education and/or self-management techniques could improve asthma symptoms and HRQoL through mechanisms of reduce depression and anxiety (panic-fear) symptoms in adults with asthma reporting panic disorder or anxiety disorder [47]. In the present study, all the healthcare clinicians were trained in cognitive behavioral therapy, relaxation techniques such as yoga, cardiac coherence, mindfulness meditation, and hypnosis, education and self-management interventions to respond to individual's needs, barriers and personal goals. This could explain the similar benefits between groups. Moreover, one to one home rehabilitation sessions are an opportunity for people to talk about the violence and traumatic experiences they had experienced. When appropriate and with their consent, participants were then advised to contact a clinician therapist to continue to deal with chronic stressors at long-term. To better help these individuals, one of the first step will be to inform healthcare professionals that chronic stress concerns a large proportion of people with severe asthma. The second step would be the training of healthcare professionals (not only therapists) by experts in this topic, for receiving and dealing with patients' emotions and their own. Finally, violence and traumatic experiences could also be addressed during group education sessions in center-based PR to give those who wish to express themselves the opportunity to do so.

The monocentric and non-randomized nature of this study may limit the scope of the present results that should be confirmed by robustly designed randomized and controlled studies. However, data were collected systematically and consistently as an integral part of the home-based PR including a large number of non-selected participants in a real-life setting. By improving external validity and establishment in usual care, real-life studies are useful to complement the results of traditional randomized controlled trial [51]. The fact that experiencing violence and/or a traumatic experience was not assess with a specific questionnaire or during a specific interview could also limit our results. Therefore, prevalence of individuals exposed to chronic stressors could be underestimated as it was not objectively assessed, and participants who decided not to talk about their chronic stress could have been misplaced. However, to be representative of the real-life individuals with asthma in clinic, we chose to include a large variety of chronic stressors (sexual, physical and/or psychological violence, community violence, intimate partner violence, being hospitalized in an intensive care unit for asthma exacerbation) that could not be assessed with a single questionnaire.

5. Conclusion

This real-life study demonstrated that a large proportion of adults with severe asthma have been exposed to chronic stressors at the time of starting a PR programme, resulting in higher anxiety symptoms and hyperventilation syndrome and a poorer quality of life. However, this did not prevent them from benefiting from PR to the same extent than individuals who did not report having exposed to a chronic stressor. This topic is poorly discussed during pulmonary rehabilitation and this study highlighted the need of informing and training healthcare professionals caring for people with asthma.

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CRediT authorship contribution statement

Sarah Gephine: Conceptualization, execution, acquisition of data, Formal analysis, interpretation, Writing – original draft. **Stéphanie Fry:** interpretation of data, Writing – review & editing. **Emilie Margoline:** interpretation of data, Writing – review & editing. **Alice Gicquello:** interpretation of data, Writing – review & editing, final approval of the version to be published. **Cécile Chenivesse:** interpretation of data, Writing – review & editing, All. **Jean-Marie Grosbois:** Funding acquisition, Conceptualization, execution, acquisition of data, data interpretation, Writing – original draft.

Declaration of competing interest

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Appendix A. Supplementary data

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