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# Comparing the effect of pulmonary rehabilitation in patients with uncontrolled and partially controlled asthma

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## ABSTRACT

**Objective:** Pulmonary rehabilitation (PR) is an important therapeutic approach in asthmatic patients. Lack of asthma control is associated with high morbidity, poor health outcomes, and decrease in quality of life (QOL). However, there is no clear information about the effectiveness of PR in patients with differing levels of asthma control. This study aimed to compare the efficacy of PR in patients with uncontrolled and partially controlled asthma. **Methods:** Before undergoing an 8-week outpatient PR program, patients were classified according to the asthma control test (ACT) as having partially controlled asthma or uncontrolled asthma. Changes in asthma control, exercise capacity, dyspnea perception, pulmonary function tests, arterial blood gas analysis, QOL, and psychological symptoms before and after PR were compared between groups. **Results:** A total of 49 patients, 21 of whom were in partially controlled and the rest 28 were in uncontrolled asthma, participated in the study. After PR, asthma control perceived dyspnea, exercise capacity, QOL, anxiety, and depression significantly improved in both groups ( $p < 0.05$ ). When the two groups were compared in terms of the benefits of PR, the improvement in ACT score was significantly greater in patients with uncontrolled asthma than in partially controlled asthma ( $p < 0.001$ ), whereas the improvements in other parameters were similar between groups ( $p > 0.05$ ). **Conclusions:** Improvement in asthma control is greater in patients with uncontrolled asthma than in patients with partially controlled asthma after PR. Therefore, patients with uncontrolled asthma, in particular, should be given opportunities to benefit from PR programs.

## ARTICLE HISTORY

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## Introduction

Asthma is a serious global health problem for all age groups and its prevalence is increasing. It is usually a heterogeneous illness characterized by chronic airway inflammation and airway hyper-responsiveness. Asthma is defined by varying degrees of airflow restriction combined with respiratory symptoms including wheezing, difficulty breathing, chest tightness, and cough (1). These symptoms lead to activity restriction and reduced exercise capacity, and patients experience comorbidities such as anxiety and depression and reduced quality of life (QOL) (2,3). In many patients with asthma, the fear of experiencing symptoms during or after exercise and the lack of encouragement to exercise by healthcare professionals cause a reduction in daily activities and a failure to exercise or participate in physical group activities (2,4). The main objective of asthma treatment is to eliminate or reduce its symptoms (5). Despite effective treatment, asthma cannot be cured and many patients worldwide live with uncontrolled asthma (6,7).

Asthma treatment is not only medical but also requires comprehensive care, including nonpharmacological treatment. Pulmonary rehabilitation (PR) has been recognized as an efficient method of nonpharmacological treatment for chronic pulmonary diseases, especially chronic obstructive pulmonary disease (7,8). Although it has been demonstrated to reduce dyspnea, anxiety, rescue medication use, and the number of emergency service admittances, patients with asthma are not routinely referred for PR (7,9).

Asthma control is characterized by symptoms, changes in pulmonary function, and effects on QOL and functional ability (10). Controlled asthma has been shown to reduce morbidity, improve QOL, increase productivity, and improve health outcomes; therefore, it is important to assess it in clinical practice (11,12).

There exist very few studies demonstrating the effect of PR on asthma control and no information on the difference in efficacy in different patient groups. Therefore, the present study aimed to assess the efficacy of PR applied

to patients with uncontrolled versus partially controlled asthma on primarily asthma control and our secondary outcomes such as pulmonary function, arterial blood gas, exercise capacity, dyspnea perception, QOL, and psychological status.

## Methods

We conducted a prospective cohort study to compare the effectiveness of PR in patients with uncontrolled and partially controlled asthma. Patients who met the inclusion criteria for the study were evaluated before the PR program. Groups were formed according to their asthma control test (ACT) results. Evaluation of groups after 8 weeks of PR program was repeated by the same clinician (see flowchart, [Figure 1](#)). The study was approved by the local institutional review board. Patients included in the PR program provided written informed consent.

## Patients

Patients referred from the outpatient asthma clinic in which the asthmatic patients were diagnosed and treated with medications to the PR unit at our institution between January 2013 and January 2017 were included in this study. Patient diagnoses were confirmed using the Global Initiative for Asthma (GINA) guidelines (1). Inclusion criteria were being clinically stable (under medical treatment for <6 months) and not having cardiovascular, other lung diseases (pneumoconiosis, pulmonary tuberculosis, interstitial lung disease), or musculoskeletal diseases that would impair exercise training. Patients with controlled asthma and who had poor compliance (not attending the program more than twice) or transportation problems were excluded from the study (8).

Patients were grouped according to ACT score before PR; those with an ACT score of 20–24 were classified as having partly controlled asthma (Group 1), and those with an ACT score of  $\leq 19$  were classified as having uncontrolled asthma (Group 2) (13,14).

## Measurements

All patients underwent cardiac and respiratory system examinations, as well as chest radiographs and arterial blood gas analysis. They were directed to the cardiology department to determine the eligibility for aerobic exercise. Pulmonary function parameters [forced expiratory volume in the 1st second (FEV<sub>1</sub> %), FEV<sub>1</sub>/forced vital capacity (FVC), peak expiratory flow (PEF %), forced expiratory flow (FEF) at 25%–75%] was assessed by

measuring body plethysmography (Zan 500, Germany) (15).

Asthma control was the primary outcome variable and was assessed using the ACT. The ACT consists of five items that assess 1) activity limitations, 2) daytime shortness of breath, 3) waking due to asthma symptoms, 4) required puffs of asthma reliever medication, and 5) global asthma control. All items refer to the last 4 weeks and are scored from 1 to 5. The sum of scores indicates overall asthma control (14). The Modified Medical Research Council (MMRC) dyspnea scale, which ranges from 1 to 5, was used to determine the dyspnea perception. Scores of 1 indicate the less dyspnea and scores of 5 indicate the more dyspnea (16). St. George's Respiratory Questionnaire (SGRQ) was used to determine the disease-specific QOL (17). High scores define worsened disease and increased symptoms. Overall QOL was assessed by the 36-Item Short-Form Health Survey (SF-36). Increased scores were considered in favor of improved QOL (18). Psychological symptoms were assessed using the Hospital Anxiety and Depression Scale (HADS). HADS is a 14-item questionnaire with 7 items assessing depressive symptoms and 7 assessing anxiety symptoms. Patients were asked to give a score ranging from 0 to 3 for each item. Scores ranged from 0 to 21, with higher scores indicating higher anxiety and depression (19). The Six-Minute Walk Test (6MWT) was performed according to the American Thoracic Society guidelines and the distance walked for 6 minutes was recorded before and after PR (20). All measurements were performed at admission and at the end of PR.

## Interventions

PR sessions, lasting 2 hours, were performed twice a week for 8 weeks. PR was completely tailored to suit the needs of each individual. The program consisted of education, supervised exercise training, nutritional intervention, and psychological counseling if needed. The exercise program included breathing exercises consisting of pursed-lip breathing, diaphragmatic breathing, thoracic expansion exercises, relaxation and stretching exercises, upper- and lower-extremity muscle strength training, and aerobic exercises. All strengthening exercises were started without weights. Patients began with 8 repetitions and progressed to 10. When the patient was able to perform the workload for 1–2 repetitions above the desired number, the load was increased by 2%–10%. Treadmill and bicycle/arm ergometer were used for aerobic exercises. We calculated workloads for both cycling and walking speed on the treadmill from results of the 6MWT (21). Patients trained at 60%–90% of their maximum heart rate.

In addition, we used Borg dyspnea scores to regulate exercise (22). Exercise intensity increased according to patient progress. Aerobic exercises were performed for 30 minutes. All patients were informed of the importance of continuing exercising at home and to continue their inhaled bronchodilator therapy during the PR program (8).

### Statistical analysis

A sample size of at least 21 participants per group was chosen to provide a power of 0.80 to detect a 3-unit increase in mean ACT score, assuming a standard deviation of 3.4 units with a two-sided test at the 0.05 level. Statistical analysis was performed using SPSS for Windows version 17. The distribution of data normality was assessed using Shapiro–Wilk test. Since the distribution of the data is not normal, continuous variables were expressed as median [interquartile range (IQR)] and categorical variables as percentages (%). Wilcoxon signed-rank test was used to compare the pre- and post-treatment values of the same group, and Mann–Whitney U test was used to compare the values of the partially controlled and uncontrolled groups. Analysis of countable variables was performed by Fisher's exact test. Test results were interpreted at a significance level of  $p < 0.05$ .

### Results

Out of 49 patients (41 female), 21 (43%) were in Group 1 and 28 (57%) in Group 2 (Figure 1). Age and body mass index (BMI) distributions of the groups were comparable ( $p = 0.083$ ,  $p = 0.321$ , respectively; Table 1). Respiratory function tests and arterial blood gas results before PR were comparable ( $p > 0.05$ , Table 1). For patients in Group 2, dyspnea perception was higher ( $p = 0.002$ ) and 6MWT distance was lower ( $p = 0.011$ , Table 1). For the QOL evaluation, all parameters of the SGRQ and many parameters of the SF-36 were found to be worse in Group 2 ( $p < 0.05$ , Table 1). Anxiety and depression scores were found to be higher in Group 2 ( $p = 0.001$ ,  $p = 0.036$ , respectively, Table 1).

After PR, significant improvement was noted in the ACT scores of both groups ( $p < 0.05$ , Table 2). No significant change was detected in pulmonary function test scores or arterial blood gas analysis of the groups after PR ( $p > 0.05$ , Table 2). Distances on the 6MWT and dyspnea perception were significantly improved in both groups after PR ( $p < 0.05$ , Table 2). In the SGRQ assessment after PR, the activity and total scores of Group 1 ( $p = 0.009$ ,  $p = 0.016$ , respectively, Table 2) and all subscores of Group 2 were significantly improved ( $p < 0.005$ , Table 2). Similarly, while many parameters of the SF-36 were

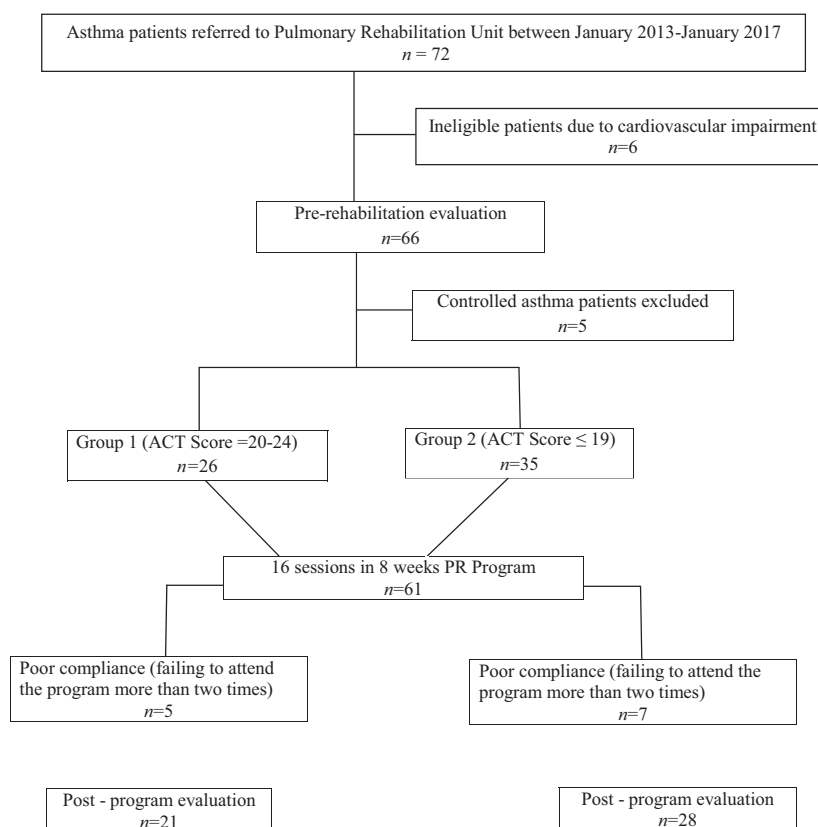


Figure 1. Flowchart. ACT, Asthma Control Test.

**Table 1.** The demographic and clinical parameters of the patients before pulmonary rehabilitation.

| Variables                                  | All Patients $n = 49$ | Partially controlled $n = 21$ | Uncontrolled $n = 28$ | $P$              |
|--------------------------------------------|-----------------------|-------------------------------|-----------------------|------------------|
| Age (years)                                | 57(49,64)             | 61(54,67)                     | 55(49,60)             | 0.083            |
| Female gender ( $n\%$ )                    | 33(80.5)              | 7(50.0)                       | 26(96.3)              | <b>0.001</b>     |
| ACT score                                  | 14(10,20)             | 21(20,21)                     | 11(8,14)              | <b>&lt;0.001</b> |
| Body mass index ( $\text{kg}/\text{m}^2$ ) | 31(28,35)             | 30(28,33)                     | 32(26,35)             | 0.321            |
| <i>Pulmonary function test</i>             |                       |                               |                       |                  |
| FEV <sub>1</sub> (%)                       | 72(52,74)             | 72(60,77)                     | 68(47,76)             | 0.505            |
| FEV <sub>1</sub> /FVC                      | 64(63,72)             | 65(60,72)                     | 64(63,70)             | 0.741            |
| PEF (%)                                    | 57(38,73)             | 72(50,98)                     | 52(36,68)             | 0.105            |
| FEF <sub>25-75</sub> (%)                   | 41(25,77)             | 73(37,87)                     | 39(23,84)             | 0.236            |
| <i>Arterial blood gas</i>                  |                       |                               |                       |                  |
| PaO <sub>2</sub>                           | 84(76,90)             | 85(75,90)                     | 84(76,90)             | 0.897            |
| PaCO <sub>2</sub>                          | 38(35,41)             | 37(34,42)                     | 39(35,41)             | 0.806            |
| SatO <sub>2</sub>                          | 97(95,97)             | 97(95,97)                     | 96(95,97)             | 0.761            |
| 6MWD (meters)                              | 380(320,440)          | 435(378,500)                  | 370(290,435)          | <b>0.011</b>     |
| MMRC                                       | 3(2,4)                | 2(1,3)                        | 3(3,4)                | <b>0.002</b>     |
| <i>SGRQ scores</i>                         |                       |                               |                       |                  |
| Symptoms                                   | 61(42,77)             | 39(25,62)                     | 65(52,83)             | <b>0.005</b>     |
| Activity                                   | 67(55,86)             | 61(39,73)                     | 68(61,93)             | <b>0.032</b>     |
| Impact                                     | 50(30,68)             | 26(19,39)                     | 58(47,71)             | <b>&lt;0.001</b> |
| Total                                      | 57(40,74)             | 36(29,50)                     | 62(50,78)             | <b>&lt;0.001</b> |
| <i>SF-36 scores</i>                        |                       |                               |                       |                  |
| Physical function                          | 55(28,70)             | 73(55,95)                     | 40(15,60)             | <b>&lt;0.001</b> |
| Social function                            | 63(31,81)             | 75(38,88)                     | 50(25,75)             | 0.107            |
| Role physical                              | 0(0,38)               | 25(0,100)                     | 0(0,25)               | 0.060            |
| Role emotional                             | 0(0,67)               | 33(0,100)                     | 0(0,33)               | 0.222            |
| General health                             | 35(18,59)             | 55(48,64)                     | 25(15,45)             | <b>0.004</b>     |
| Mental health                              | 52(32,74)             | 64(51,88)                     | 48(32,68)             | <b>0.037</b>     |
| Bodily pain                                | 41(22,73)             | 72(62,90)                     | 32(22,51)             | <b>0.001</b>     |
| Vitality                                   | 40(20,68)             | 60(41,83)                     | 30(15,60)             | <b>0.009</b>     |
| <i>HAD scores</i>                          |                       |                               |                       |                  |
| Anxiety                                    | 8(4,15)               | 5(3,8)                        | 12(6,16)              | <b>0.001</b>     |
| Depression                                 | 8(5,10)               | 5(3,9)                        | 9(7,11)               | <b>0.036</b>     |

Note. Data are expressed as median (interquartile range) or  $n(\%)$ , \* MannWhitney-U Test, ACT: Asthma Control Test, FEV<sub>1</sub>: Forced Expiratory Volume in the 1st Second, FVC: Forced Vital Capacity, PEF: Peak Expiratory Flow, FEF<sub>25-75</sub>: Forced Expiratory Flow (midexpiratory phase), PaO<sub>2</sub>: Partial Arterial Oxygen Pressure, PaCO<sub>2</sub>: Partial Arterial Carbon Dioxide Pressure, SaO<sub>2</sub>: Arterial Oxygen Saturation, 6MWD: Six-Minute Walk Distance, MMRC: Modified Medical Research Council, SGRQ: St. George Respiratory Questionnaire, SF-36: Short-Form Health Survey, HAD: Hospital Anxiety and Depression Scale.

improved in Group 2 ( $p < 0.05$ , Table 2), significant differences were only detected for the emotional role and vitality scores in Group 1 ( $p = 0.019$ ,  $p = 0.045$ , respectively, Table 2). Anxiety and depression scores were significantly decreased in both groups ( $p < 0.05$ , Table 2).

When the two groups were compared in terms of the benefits of PR; the increase in ACT score was significantly greater in Group 2 than that in Group 1 ( $p < 0.001$ , Table 3), whereas the other improvements were found to be similar ( $p > 0.05$ ).

## Discussion

In this study, we investigated the effect of PR in patients with different levels of asthma control we found improvements in asthma control, exercise capacity, dyspnea perception, QOL, anxiety, and depression in all patients but more improvement in asthma control in patients with uncontrolled asthma.

Aerobic exercise training plays an important role in the clinical management of persistent asthma (4). Lingner et al. found that ACT scores were significantly

improved after PR was administered to hospitalized asthma patients, and this improvement was maintained at 3, 6, and 12 months (23). Similarly, in our study, there was a significant improvement after PR in the ACT scores of both groups, and the improvement observed in uncontrolled group was significantly greater than in partially controlled group. Moreover, the improvements in ACT scores in both groups of our study were higher than the minimal clinically important difference, which is defined in the literature as a change of 3 units (10).

Asthma is more common and more severe in women (24). In our study, the number of female patients in the uncontrolled group was significantly higher compared to partially controlled group. From this point of view, our study is consistent with the knowledge that asthma control is poorer in women patients (25). Many prospective trials have demonstrated that obesity is a risk factor for asthma, and there is a positive correlation between BMI and asthma (26). In accordance with the literature, the median BMI of our patients was over 30, and there was no significant difference between groups.

**Table 2.** The comparison of clinical parameters before and after pulmonary rehabilitation in groups.

|                             | Partially controlled <i>n</i> = 21 |              |                         | Uncontrolled <i>n</i> = 28 |              |                         |
|-----------------------------|------------------------------------|--------------|-------------------------|----------------------------|--------------|-------------------------|
|                             | BPR                                | APR          | <i>P</i> <sub>1</sub> * | BPR                        | APR          | <i>P</i> <sub>2</sub> * |
| ACT score                   | 21(20,21)                          | 24(23,25)    | <b>0.001</b>            | 11(8,14)                   | 21(16,22)    | <b>&lt;0.001</b>        |
| <i>PFT</i>                  |                                    |              |                         |                            |              |                         |
| FEV <sub>1</sub> (%)        | 72(60,77)                          | 73(64,81)    | 0.234                   | 68(47,76)                  | 71(44,72)    | 0.484                   |
| FEV <sub>1</sub> /FVC       | 65(60,72)                          | 70(60,77)    | 0.396                   | 64(63,70)                  | 67(64,75)    | 0.474                   |
| PEF(%)                      | 72(50,98)                          | 79(56,96)    | 0.500                   | 52(36,68)                  | 53(38,68)    | 0.972                   |
| FEF <sub>25-75</sub> (%)    | 73(37,87)                          | 59(38,83)    | 0.686                   | 39(23,84)                  | 43(29,59)    | 0.600                   |
| <i>Arterial blood gases</i> |                                    |              |                         |                            |              |                         |
| PaO <sub>2</sub>            | 85(75,90)                          | 86(77,95)    | 0.414                   | 84(76,90)                  | 83(75,91)    | 0.808                   |
| PaCO <sub>2</sub>           | 37(34,42)                          | 39(37,41)    | 0.379                   | 39(35,41)                  | 38(35,41)    | 0.886                   |
| SaO <sub>2</sub>            | 97(95,97)                          | 97(96,97)    | 0.824                   | 96(95,97)                  | 96(95,97)    | 0.156                   |
| 6MWD (meter)                | 435(378,500)                       | 480(443,520) | 0.001                   | 370(290,435)               | 390(350,470) | <0.001                  |
| MMRC                        | 2(1,3)                             | 1(1,2)       | 0.010                   | 3(3,4)                     | 3(2,3)       | 0.001                   |
| <i>SGRQ scores</i>          |                                    |              |                         |                            |              |                         |
| Symptom                     | 39(25,62)                          | 40(28,55)    | 0.331                   | 65(52,83)                  | 55(48,61)    | 0.001                   |
| Activity                    | 61(39,73)                          | 36(11,55)    | 0.009                   | 68(61,93)                  | 60(42,86)    | 0.002                   |
| Impact                      | 26(19,39)                          | 18(10,36)    | 0.074                   | 58(47,71)                  | 45(31,69)    | 0.001                   |
| Total                       | 36(29,50)                          | 26(16,48)    | 0.016                   | 62(50,78)                  | 54(37,61)    | <0.001                  |
| <i>SF-36 scores</i>         |                                    |              |                         |                            |              |                         |
| Physical function           | 73(55,95)                          | 95(68,100)   | 0.113                   | 40(15,60)                  | 60(30,75)    | 0.002                   |
| Social function             | 75(38,88)                          | 63(50,100)   | 0.279                   | 50(25,75)                  | 63(50,88)    | 0.131                   |
| Role physical               | 25(0,100)                          | 100(25,100)  | 0.051                   | 0(0,25)                    | 25(0,100)    | 0.001                   |
| Role emotional              | 33(0,100)                          | 100(66,100)  | 0.019                   | 0(0,33)                    | 33(0,67)     | 0.012                   |
| General health              | 55(48,64)                          | 56(35,70)    | 0.850                   | 25(15,45)                  | 37(20,57)    | 0.018                   |
| Mental health               | 64(51,88)                          | 72(40,89)    | 0.350                   | 48(32,68)                  | 64(36,84)    | 0.024                   |
| Bodily pain                 | 72(62,90)                          | 90(52,100)   | 0.259                   | 32(22,51)                  | 61(41,84)    | <0.001                  |
| Vitality                    | 60(41,83)                          | 68(49,93)    | 0.045                   | 30(15,60)                  | 50(40,70)    | 0.001                   |
| <i>HAD scores</i>           |                                    |              |                         |                            |              |                         |
| Anxiety                     | 5(3,8)                             | 4(2,7)       | 0.032                   | 12(6,16)                   | 8(5,12)      | <b>0.002</b>            |
| Depression                  | 5(3,9)                             | 4(1,7)       | 0.011                   | 9(7,11)                    | 6(4,11)      | <b>0.007</b>            |

Note. Data are expressed as median (interquartilerange), \* Wilcoxon Signed Rank Test, BPR: Before Pulmonary Rehabilitation, APR: After Pulmonary Rehabilitation, ACT: Asthma Control Test, FEV<sub>1</sub>: Forced Expiratory Volume in the 1st Second, FVC: Forced Vital Capacity, PEF: Peak Expiratory Flow, FEF<sub>25-75</sub>: Forced Expiratory Flow (midexpiratory phase), PaO<sub>2</sub>: Partial Arterial Oxygen Pressure, PaCO<sub>2</sub>: Partial Arterial Carbon Dioxide Pressure, SaO<sub>2</sub>: Arterial Oxygen Saturation, 6MWD: Six-Minute Walk Distance, MMRC: Modified Medical Research Council, SGRQ: St. George Respiratory Questionnaire, SF-36: Short-Form Health Survey, HAD: Hospital Anxiety and Depression Scale

P1: Comparison of clinical parameters before and after pulmonary rehabilitation in patients have poor asthma control, P2: Comparison of clinical parameters before and after pulmonary rehabilitation in patients have no asthma control

As with all obstructive diseases, FEV<sub>1</sub> and FEV<sub>1</sub>/FVC values are the best indicators of obstruction of asthma. If the FEV<sub>1</sub> value is less than 80% and the FEV<sub>1</sub>/FVC value is less than 75%–80% in asthma, then the patient is considered to have obstruction (1). All the patients in our study had FEV<sub>1</sub> values less than 80% and FEV<sub>1</sub>/FVC values less than 75%; these scores were similar between groups. FEF<sub>2575</sub> value is independent of effort and shows the condition of the small airways. For patients with suspected asthma, a reduced FEF<sub>2575</sub> value may be considered significant, even if other pulmonary parameters are normal (27). The FEF<sub>2575</sub> value was found to be low in both groups in our study, and no significant difference was found between groups. PEF measurement is an auxiliary test for the diagnosis and monitoring of asthma. In many patients, there is no correlation between the PEF value and other pulmonary parameters (27). In our study, although the PEF value of the uncontrolled group was lower than that of Group 1, this difference was not statistically significant.

The exercise tolerance of asthma patients is reduced due to worsening asthma symptoms during exercise and

deconditioning caused by inactivity (28). In this study, the 6MWT distance was significantly lower and dyspnea perception significantly higher in uncontrolled group than in partially controlled group before PR.

Currently, many of the asthma patients have uncontrolled asthma, and this condition is associated with a significant difference in the QOL (6,12). The reduction in daily activities due to asthma symptoms leads to a limited social life in many patients (4). In our study, the patients in uncontrolled group had poorer scores for all parameters of the disease-related QOL questionnaire and for many parameters of the health-related QOL questionnaire. Previous research has documented an association between psychological disorders, poor asthma control, and QOL (29). In our study, both the anxiety and depression scores were significantly higher in patients with uncontrolled asthma.

As in some previous studies (4,30), no significant difference was found in the pulmonary function tests of patients after PR in our study. However, in another study, FEV<sub>1</sub>, vital capacity (VC), and FEV<sub>1</sub>/VC values were reported to be significantly improved in patients with

**Table 3.** The comparison of changes of the outcomes between groups.

| Variables                 | Partially controlled<br><i>n</i> = 21 | Uncontrolled<br><i>n</i> = 28 | <i>P</i> *       |
|---------------------------|---------------------------------------|-------------------------------|------------------|
| ΔACT score                | 3(2,4)                                | 7(6,10)                       | <b>&lt;0.001</b> |
| ΔPFT                      |                                       |                               |                  |
| ΔFEV <sub>1</sub> (%)     | 3(−2,7)                               | 2(−5,7)                       | 0.148            |
| ΔFEV <sub>1</sub> /FVC    | 4(−7,9)                               | 2(−5,7)                       | 0.160            |
| PEF(%)                    | 6(−17,25)                             | −1(−12,10)                    | 0.657            |
| FEF <sub>25–75</sub> (%)  | 4(−21,8)                              | −2(−14,10)                    | 0.961            |
| <i>Arterial blood gas</i> |                                       |                               |                  |
| PaO <sub>2</sub>          | 3(−4,7)                               | −1(−6,6)                      | 0.573            |
| PaCO <sub>2</sub>         | 0(−4,5)                               | 1(−3,4)                       | 0.654            |
| SatO <sub>2</sub>         | 0(−1,2)                               | 0(−3,1)                       | 0.346            |
| Δ6MWD (meters)            | 40(20,70)                             | 40(10,60)                     | 0.534            |
| ΔMMRC                     | −1(−1,0)                              | −1(−1,0)                      | 0.801            |
| <i>ΔSGRQ scores</i>       |                                       |                               |                  |
| ΔSymptoms                 | −5(−14,5)                             | −10(−21,1)                    | 0.206            |
| ΔActivity                 | −16(−33, −2)                          | −7(−20,0)                     | 0.277            |
| ΔImpact                   | −7(−20,1)                             | −12(−25, −4)                  | 0.284            |
| ΔTotal                    | −9(−20, −2)                           | −10(−19, −5)                  | 0.783            |
| <i>ΔSF-36 scores</i>      |                                       |                               |                  |
| ΔPhysical function        | 5(0,25)                               | 15(0,30)                      | 0.599            |
| ΔSocial function          | 13(0,25)                              | 13(−13,25)                    | 0.448            |
| ΔRole physical            | 13(−6,81)                             | 0(0,75)                       | 0.840            |
| ΔRole emotional           | 17(0,100)                             | 0(0,33)                       | 0.261            |
| ΔGeneral health           | 7(−16,11)                             | 10(0,20)                      | 0.190            |
| ΔMental health            | 2(−9,21)                              | 8(0,32)                       | 0.362            |
| ΔBodily pain              | 0(−3,28)                              | 19(0,29)                      | 0.113            |
| ΔVitality                 | 8(0,16)                               | 15(0,30)                      | 0.230            |
| <i>ΔHAD scores</i>        |                                       |                               |                  |
| ΔAnxiety                  | −2(−2, −1)                            | −1(−5,0)                      | 0.470            |
| ΔDepression               | −2(−3,0)                              | −1(−4,0)                      | 0.857            |

Note. Data are expressed as median (interquartile range). Results are shown as change between posttreatment and baseline levels (Δ values),\* Mann–Whitney-U Test, ACT: Asthma Control Test, FEV<sub>1</sub>: Forced Expiratory Volume in the 1st Second, PEF: Peak Expiratory Flow, FEF<sub>25–75</sub>: Forced Expiratory Flow(midexpiratory phase), PaO<sub>2</sub>: Partial Arterial Oxygen Pressure, PaCO<sub>2</sub>: Partial Arterial Carbon Dioxide Pressure, SaO<sub>2</sub>: Arterial Oxygen Saturation, 6MWD: Six-Minute Walk Distance, MMRC: Modified Medical Research Council, SGRQ: St. George Respiratory Questionnaire, SF-36: Short-Form Health Survey, HAD: Hospital Anxiety and Depression Scale

asthma after PR. In a separate study, the improvement in maximal expiratory flow at 75% of VC values after PR combined with subterranean therapy in patients with uncontrolled and partially controlled asthma was found to be significant (3).

Another previous study reported a significant improvement in 6MWT distance after 3 weeks of PR was administered to hospitalized patients with asthma (23). It was found that the aerobic capacity and number of symptom-free days were found to be increased after PR was administered to patients with moderately to severely persistent asthma, and a linear correlation was reported between these two parameters (4). Finally, another study assessed the exercise capacity after PR was administered to patients with severe asthma using the incremental shuttle walk test and endurance shuttle walk test, and found both to be significantly improved (31).

Asthma remains an incurable condition, and the main objective of treatment is symptom control (3,9). As with

the study showing that the Medical Research Council (MRC) score is significantly decreased after PR (31), in our study, the MRC score was also significantly decreased in both groups.

In several previous studies, an improvement in the QOL was found after PR was administered to patients with asthma (2,4,23,30). Moreover, anxiety and depression scores were significantly decreased after PR (2,4,30,31). In our study, disease- and health-related QOL scores were significantly improved in both groups, with the uncontrolled group experiencing improvements in a greater number of parameters. Furthermore, the anxiety and depression scores were significantly decreased in both the groups. When improvements after PR were compared, no significant difference was found between the groups.

Our study was continued until at least 21 patients in both groups completed the program to achieve statistical power, and during that time comparatively more patients with uncontrolled asthma were referred to the PR unit similar to the routine. This is why the number of patients in our study groups is different.

During the study period, we had 5 patients from the partially controlled group and 7 patients from the uncontrolled group who dropped out of the program. However, this did not constitute a problem in terms of statistics because the continuous and categorical data of the patients leaving the study were similar to the remaining ones.

A major strength of our study is that it is the first report to evaluate the benefits of PR in patients with uncontrolled and partially controlled asthma. Despite the fact that the number of cases in our study is enough for the statistical power to detect the effectiveness of PR in patients with different asthma control, there is a need for larger studies on subgroup analyzes, such as obesity and gender. Although the SGRQ is a valid questionnaire for use in patients with asthma, the fact that we did not use a questionnaire specific to asthma may be a limitation of our study. Additionally, we did not examine patients' sociodemographic characteristics in detail, which prevented us from making comparisons of these parameters between groups.

## Conclusion

A PR program, combined with medical treatment, represents an effective means of controlling asthma, particularly in uncontrolled asthmatic patients. Therefore, patients with uncontrolled asthma should be given opportunities to benefit from PR programs. In addition, PR applied to asthma patients improves their dyspnea perception, exercise capacity, QOL, and psychological status.

## Disclosure of interest

No potential conflicts of interest were disclosed.

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