

ORIGINAL ARTICLE

Asthma control and health-related quality of life one year after inpatient pulmonary rehabilitation: the ProKAR StudyHeidrun Lingner, MD¹, Stefanie Ernst², Anika Großhennig, PhD², Nino Djahangiri, MD³, David Scheub, MD⁴, Michael Wittmann, MD³, and Konrad Schultz, MD³¹Centre for Public Healthcare, Hannover Medical School, Hannover, Germany, ²Institute for Biometrics, Hannover Medical School, Hannover, Germany, ³Bad Reichenhall Clinic, Centre for Rehabilitation, Pneumology and Orthopedics, Bad Reichenhall, Germany, and ⁴Alb Clinic, Internal Medicine, Reutlingen, Germany**Abstract**

Objectives: Although pulmonary rehabilitation (PR) is commonly used for asthmatics in many countries, so far there are no studies addressing the question of whether and for how long an improvement in asthma control (AC) is seen after rehabilitation. The ProKAR study (Prospektive Katamnesestudie Asthma-Rehabilitation) was performed to provide data concerning the short- and long-term impact of PR on AC. **Methods:** Two-hundred one adult patients with mild to severe persistent asthma were prospectively followed one year after completion of a 3-week PR program. AC, the primary outcome parameter, and health-related quality of life (HRQoL) were monitored using the Asthma Control Test (ACT) and St. George's Respiratory Questionnaire (SGRQ) at initiation (T0) and end of the PR (T1) and 3, 6 and 12 months thereafter. Pulmonary function, physical fitness (6MWD) and asthmatic inflammation (FENO) were measured at T0 and T1. **Results:** The proportion of patients with well-controlled asthma (ACT score ≥ 20) increased from 33.2% to 67.3% after PR and was still at 51% after 12 months. Slight but statistically significant improvements in pulmonary functions and an increase in 6MWD of nearly 60 m were reported at T1. One year after discharge 55.8% of the patients still showed a clinically relevant improvement of at least 4 points in the total SGRQ score. **Conclusions:** The multidisciplinary inpatient PR program resulted in significant short and long-term improvement in AC and HRQoL in adult asthmatic patients.

Keywords

Asthma control test, multidisciplinary/multimodal rehabilitation program, physical ability or exercise tolerance (6MWD), pulmonary function, short- and long-term asthma control

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Published online 13 January 2015**Introduction**

Pulmonary rehabilitation (PR) is widely accepted as an effective treatment for patients with chronic respiratory diseases, especially for chronic obstructive pulmonary disease (COPD) [1]. In Germany and many other countries asthma patients are also commonly enrolled in PR programmes [2,3], but very few studies or surveys assessing the efficacy of PR for asthma have been published [4–6]. However, the effectiveness of individual components of PR, such as patient education [7,8], respiratory physiotherapy [9,10] and training therapy [11–14] has been shown. As a complete PR program is expected to be at least as effective as these single components, the German National Disease Management Guidelines [15] recommends PR for asthma patients when constraining physical, mental or social consequences of the illness persist during daily life despite adequate medical therapy.

In 2006, the Global Initiative for Asthma (GINA) adopted a new patient management system based on asthma control (AC) rather than the degree of asthma severity [16]. In 2009, this amendment was integrated into the German National Disease Management Guidelines. The six AC criteria are as follows: (1) symptoms during the day, (2) symptoms at night, (3) the use of reliever medication, (4) limitation of activities, (5) pulmonary function and (6) exacerbation. Based on these criteria, asthma is classified as “controlled”, “partially controlled” and “uncontrolled”.

Until now, however, no study has analyzed the impact and long-term effects of a complete PR program on AC. ProKAR (Prospektive Katamnesestudie Asthma-Rehabilitation) was designed to prospectively assess the impact on AC of a multimodal 3-week-inpatient pulmonary rehabilitation program for adult asthmatic patients in a real-life setting. The primary outcome parameter was therefore AC, determined using the validated Asthma Control Test (ACT) [17], before (T0), immediately after (T1) and 3, 6 and 12 (T2, T3, T4) months after a 3-week inpatient PR program. The following routine parameters were also documented at T0 and T1: pulmonary function [forced expiratory volume in 1 second (FEV1) (Table 1), total specific resistance (SRtot) and vital

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Table 1. Pulmonary function at baseline T0.

	Before bronchodilator inhalation		After bronchodilator inhalation	
	Mean	SD	Mean	SD
FEV ₁ (l)	2.92	0.85	3.14	0.88
FEV ₁ (% predicted)	90.46	21.93	96.83	19.40
FEV ₁ /VC (%)	73.32	10.80	75.77	10.17
VC (l)	3.98	0.99	4.15	1.01
VC (% predicted)	97.72	15.85	101.63	14.40
sRtot (kPa*s)	1.23	0.79	0.88	0.54
sRtot (% predicted)	114.51	73.00	82.62	49.61

Parameters measured before and after inhalation of a short-acting β_2 -agonist. FEV₁: forced expiratory volume in 1 s; VC: vital capacity; sRtot: total specific resistance

capacity (VC)], physical ability [the six-minute walk distance (6MWD)] and severity of asthmatic inflammation [fractional exhaled nitric oxide (FENO)]. The secondary outcome parameter of health-related quality of life (HRQoL) was recorded at T0–T4 using the St. George's Respiratory Questionnaire (SGRQ) [18].

Methods

Patient selection

Inpatient rehabilitation is a statutorily regulated part of the German healthcare system, access to which is only possible after a thorough investigation by physicians specialized in social medicine to prove that all medical outpatient treatment options have been exhausted. The most important criteria for the approval of pulmonary rehabilitation for a patient are the persistence of physical, social or psychological consequences of the disease, which limit normal activities or the participation in a normal professional and/or social life despite adequate medical outpatient treatment, in particular persistent asthmatic symptoms with a reduced ability to work [15,19]. As in Germany rehabilitation is almost exclusively inpatient in format and lasts for three weeks it is costly to the health insurers (as there is only little financial contribution from the patients themselves). The referral criteria are therefore observed strictly.

The recruitment of participants lasted from 1 May to 30 September 2009. All patients admitted to the Bad Reichenhall center for pulmonary inpatient rehabilitation had been referred by the German statutory healthcare system. Out of the 1058 adults with various chronic respiratory diseases and different pulmonary conditions admitted to the clinic during the recruitment period, 242 patients had asthma as their primary diagnosis and were invited to participate in the study.

The diagnosis of asthma, allowing inclusion in ProKAR, was confirmed by a pneumologist upon admission to the rehabilitation program according to the asthma treatment guidelines using the following criteria: (1) asthma-specific symptoms and (2) documented reversible bronchial obstruction (increase in FEV₁ of $\geq 15\%$ and ≥ 200 ml) after administration of a bronchodilator or (3) documented bronchial hyper-reactivity demonstrated by a bronchial challenge test or peak flow diary. All data listed above were measured

or re-measured in the Bad Reichenhall Clinic upon admission and discharge.

The exclusion criteria were: (1) lack of German language skills, (2) inability to understand and complete the study questionnaires due to poor cognitive abilities and (3) co-existence of COPD. For this purpose, COPD was defined as irreversible or barely reversible obstruction with persistent airflow limitation (post-bronchodilator FEV₁/FVC < 0.7) and a corresponding medical case history, for instance a failure to respond to inhaled or systemic steroids that was noted in the patients' history, or proven lung emphysema.

The ProKAR study was initiated after receiving approval from the ethics committee of the Hannover Medical School.

Intervention

Following the structural requirements of German healthcare insurance providers [20,21] the 3-week inpatient rehabilitation program included a visit from a pulmonologist at least once a week to every patient, during which rehabilitation targets were checked. Following these visits, if required, the rehabilitation programme was modified to correspond to the altered clinical picture, for example if orthopaedic problems, infections or intercurrent illnesses were observed. Asthma medication, which in general did not require any adjustment, was also temporarily revised for a small minority of patients when new illnesses such as a common cold occurred at the same time as an asthma exacerbation. In addition to these ward rounds, the rehabilitation programme consisted of the following obligate elements:

- Structured patient education: 4 sessions (7 h in total)
- One session of practical medical inhalation training/peak flow meter training (1 h)
- Endurance training: 5 sessions/week (each 30–45 min)
- Resistance training: 3 sessions/week (each 60 min)
- Respiratory physiotherapy: 3 group sessions/week (each 30–45 min)

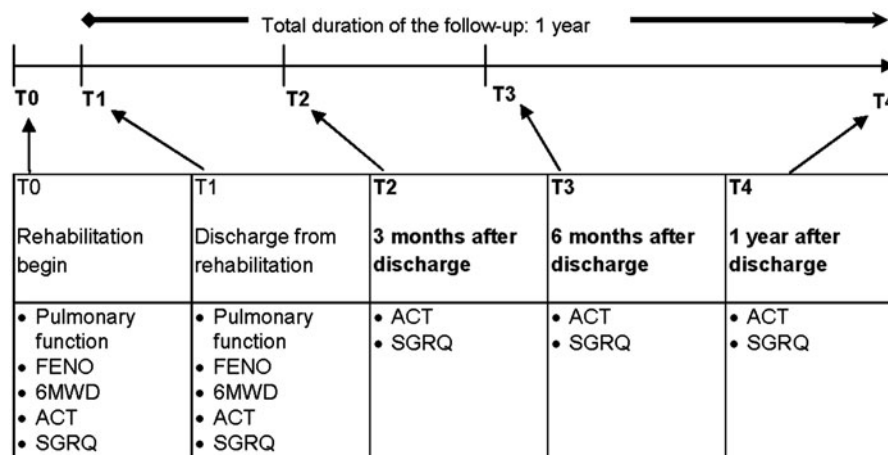
The PR program was tailored individually for each patient's needs and usually included one or more of the following optional components:

- Allergy awareness and trigger avoidance training (1 h)
- Smoking cessation program
- Psychosocial support (individual and group interventions and social counselling)
- Relaxation techniques (Autogenic Training, Progressive Muscular Relaxation)
- Ergotherapy
- Saline inhalation/exercises to facilitate mucolytic drainage
- Other types of balneotherapy (i.e. massages, medicinal baths or heat packs)
- Individual respiratory physiotherapy
- Nutritional counseling

Data collection and compilation

Figure 1 shows how the primary and secondary outcome parameters were collected: AC and HRQoL were monitored at the start of rehabilitation (T0), at discharge (T1) and 3, 6 and 12 (T2, T3, T4) months after a 3-week inpatient PR program. AC and HRQoL data were collected using paper

Figure 1. Survey times and outcome parameters.



questionnaires (ACT and SGRQ) returned by the patients: T0 and T1 were submitted on site, T2–T4 were posted. The ProKAR-patients completed all questionnaires without support. The following clinical parameters measured at T0 and T1 were documented using medical survey forms: pulmonary function (FEV1, sRtot and VC), physical ability or exercise tolerance (6MWD) and severity of asthmatic inflammation (FENO). All questionnaires and documents were de-identified in Bad Reichenhall and sent to the Hannover Medical School for digitalization by persons not involved in patient care (independent double data entry by two individuals).

Long-term outcome parameters

Primary outcome parameter

The primary outcome parameter is the degree of AC graded according to the results of the ACT over a 12 month period (T0–T4) after PR. The ACT comprises 5 empirically developed sections to rank limitations of activities, shortness of breath, asthma symptoms, need for rescue inhaler and subjective estimation of asthma control, each from 1 to 5. An ACT score of 25 indicates complete AC, a score of 20–24 indicates well-controlled asthma and of <20 indicates uncontrolled asthma.

Secondary long-term outcome parameter

The secondary long-term outcome is HRQoL, which was graded according to SGRQ scores over the 12 month period (T0–T4) after PR. This questionnaire has been validated for COPD and asthma patients [22] and consists of 76 items. A German version of SGRQ reduced to 50 items has been available since 1999 and was used in ProKAR. The total score and the three sub scores: “Symptoms”, “activity” and “impacts” range between 0 and 100, where 0 indicates no impairment and 100 indicates maximum impairment. The minimal clinically important difference (MCID) of the SGRQ total score has been set at 4 points [23].

Short-term outcome parameters

Pulmonary function, namely FEV1, total specific resistance sRtot and VC were measured by spirometry and body plethysmography using a Masterlab 4.0 (Jaeger,

Hoechberg, Germany). The data were recorded at the start (T0) and end (T1) of the PR program, before and after a short-term bronchodilator reversibility test.

FENO: The concentration of exhaled nitric oxide correlates with the level of asthmatic inflammation in the respiratory system. The current American Thoracic Society (ATS) guidelines suggest a FENO test to monitor respiratory inflammation in asthmatic patients [24]. Values of <25 ppb argue against a significant eosinophilic inflammation, values in the 25–50 ppb range indicate moderate eosinophilic inflammation and values of >50 ppb indicate severe asthmatic inflammation [24]. The FENO tests were conducted using the NIOX MINO device (Aerocrine AB, Solna, Sweden).

The 6MWT is a standard test of exercise tolerance used worldwide to evaluate patients with chronic respiratory diseases. Corresponding to the ATS guidelines [25] patients are asked to walk the longest distance possible on a hard flat surface (length 30 m) over a 6 min time-period (6MWD).

Statistical analysis

The ProKAR is an exploratory study, *p*-values are considered to be of importance for $p \leq 0.05$. No adjustment for multiplicity has been performed. Descriptive evaluation of clinical characteristics was conducted. Changes from baseline for continuous data were compared by paired *t*-tests. Correlation coefficients were listed with their *p*-values for testing the null hypothesis (correlation of zero).

Missing values were not carried forward (LOCF) to avoid an overestimation of the positive effects of PR, as the earlier time points showed greater effects of the PR. To determine the influences of diseases on ACT and SGRQ scores, the patients were grouped into the following categories, according to their co-morbidities: cardiovascular disease, metabolic diseases, musculoskeletal diseases, psychological diseases and other diseases. Two-sided *t*-tests were performed, and the results compared with the values for the total population. All statistical analyses were conducted using the SAS 9.3 software (SAS Institute Inc., Cary, NC).

Results

Two-hundred one (83.1%) eligible asthma patients were enrolled in the ProKAR study after providing individual

written informed consent. 24 (9.9 %) of the 242 asthmatic rehabilitation patients had to be excluded by the recruiting physicians: 13 because of poor German language knowledge; 16 patients declined (6.6%) and 1 stopped participating after 1 day for personal reasons.

The primary diagnosis leading to the referral for rehabilitation was always asthma, but for 11 patients co-morbidities such as severe depression or decompensated congestive heart failure were clearly clinically more important than asthma upon admission and subsequently could obscure all the effects of rehabilitation on their asthma. Moreover, in these patients the standard rehabilitation programme could only be carried out to a limited extent as the treatment of the other clinical problems took priority. These patients were therefore unsuited for assessing the effects of pulmonary rehabilitation on asthma progression and were, for this reason, excluded from the study.

The response rate for the ACT and SGRQ at T0 and T1 was 100%. The response rate for the posted questionnaires at T2, T3 and T4 was 83%, 88% and 73%, respectively. A total of 128 patients (63.7%) completed all questionnaires at all time points.

Patients' characteristics

The mean age of the patients was 48.4 (range, 18–81) years; 58% of patients were male. The study group comprised patients with extrinsic (allergic) asthma (21%), intrinsic asthma (27%) or mixed asthma (52%). At the start of the PR program, the mean sRtot was marginally elevated, but normalized after administration of an inhaled beta-2-agonist (Table 2). In addition to asthma, all patients exhibited at least one somatic (87.1%) or mental (18.9%) comorbidity, most commonly musculoskeletal (79.1%), metabolic (49.3 %), or cardiovascular (37.3 %) disorders; 42.3% had an allergic rhino conjunctivitis. At the onset of the PR program, 57% of patients suffered from asthma with grade 3–4 severity (GINA classification), i.e. moderate-to-severe persistent asthma. 13% of patients were active smokers while 29% were former smokers.

Only 6% of patients had retired; of the rest, 80% were employed, 13% were on sick leave and unable to work and 7%

were able to work but unemployed (including housewives). Working patients missed a mean of 37 days of work per year; 53.9% missed 0–20 days, 16.9% missed 21–40 days, 11.0% missed 41–80 days and 18.2% missed >80 days. At the start of the rehabilitation program the patients were already receiving adequate medication. 30% had taken part in the German disease management program for asthma.

Impact of PR on long-term AC

The long-term impact of PR on AC was determined by comparing the average ACT scores obtained over 12 months. Figure 2 shows that the number of patients with complete or well-controlled asthma (ACT score ≥ 20) increased from 33.2% at baseline (T0) to 67.3% at discharge (T1), and remained at 51.0% after one year (Figure 2A). The average ACT score had significantly improved by the end of the program (4.58 points; $p < 0.0001$; Figure 2B). During the 3–12-month period after PR, the patients maintained an average ACT score statistically significantly higher than baseline, with an average benefit of 2.48 points after one year ($p < 0.0001$; Figure 2B). An increase in total ACT score of ≥ 3 points is considered to be a clinically relevant improvement [26] and was achieved by 65.3%, 50.0%, 40.3% and 44.8% of patients directly and at 3, 6 and 12 months after PR, respectively. As only returned questionnaires were included in the data analysis the results are always presented in percentage terms.

Following sub-group analysis, no influence of co-morbidity on ACT outcome was detected. Estimates for means and confidence intervals were comparable.

Short-term impact of pulmonary rehabilitation on clinical parameters

As all patients were on adequate medication at the start of the rehabilitation programme, the lung function values were on average only marginally reduced. At the end of the rehabilitation there was a slight but statistically significant improvement in FEV₁, VC, FEV₁/VC and sRtot values compared with those at baseline T0 (Table 3). The mean pre-bronchodilator FEV₁, i.e. before the application of short- or long-acting inhaled bronchodilators, increased at T1 by 180 ml. In individual cases, for 64 patients, the pre-bronchodilator FEV₁ improved by > 200 ml from T0 to T1, which is regarded as clinically significant [27]. The slightly elevated mean pre-bronchodilator sRtot value at T0 also became almost normal at T1 (according to [28]).

Clinically relevant improvement in physical function after PR was assessed using the 6MWD results and FENO values (Table 3). There was a statistically significant improvement in exercise tolerance by the end of the 3-week program: the 6MWD was extended by approximately 60 m on average. In addition, the baseline FENO values decreased to levels within the normal range as defined by the ATS Clinical Practice Guidelines [24] after the PR program.

Long-term impact of pulmonary rehabilitation on quality of life

The PR program enhanced the HRQoL of the patients for at least one year after discharge from the treatment centre, as

Table 2. Clinically relevant Co morbidities of ProKAR participants.

Co-morbidities	Incidence*
Cardiovascular diseases	75 (37.3%)
Hypertension (67), coronarv heart disease (6), arrhythmia (6), others (11)	
Musculoskeletal disorders	159 (79.1%)
Spine syndromes (143), arthrosis (41), others (28)	
Metabolic disorders and adiposity	99 (49.3%)
Adiposity (BMI > 30:87), hyperlipidemia (25), diabetes (14), others (6)	
Allergic rhinocoujunctivitis	85 (42.3 %)
Other somatic comorbidities	80 (39.8%)
GERD (20), sleep apnea (18), thyroid disorders (29), others (50)	
Others	57 (28.4%)
Depression (24), panic attacks/anxiety disorder (6), psychovegative disorder (32), others (10)	

*Total number of patients with at least one illness out of 201 ProKAR participants. BMI: body mass index; GERD: gastrointestinal reflux disease.

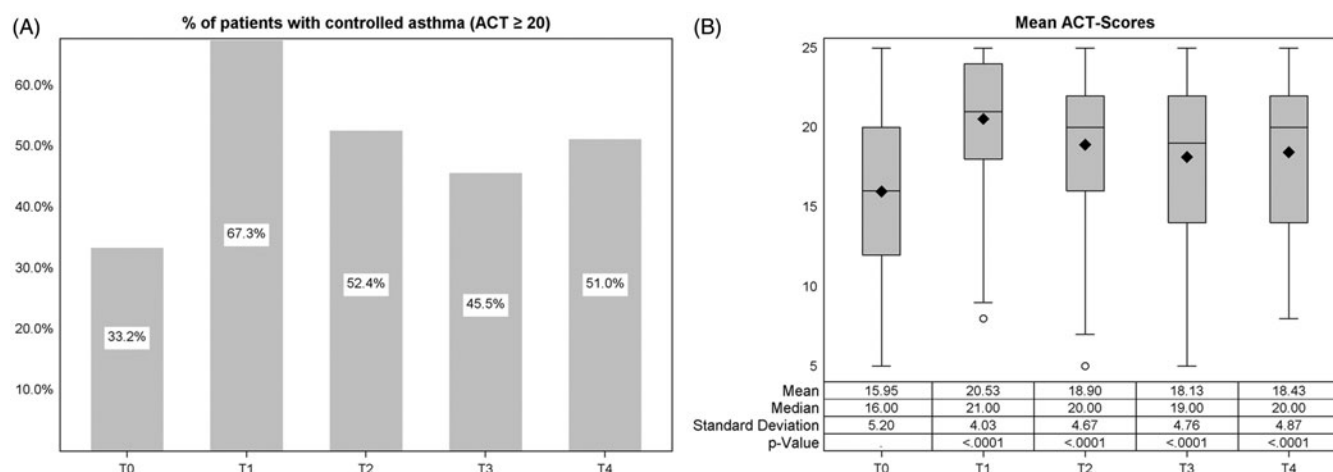


Figure 2. Development of asthma control (T0-T4).

Table 3. Impact of PR on lung function, 6MWD and FENO.

Difference between T1-T0 before bronchodilator therapy		
FEV ₁ (l)	Mean	+0.18
	95% CI	[0.12; +0.23]
	N	199
	p Value	<0.0001
FEV ₁ /VC (%)	Mean	+2.14
	95% CI	[1.19; 3.08]
	N	199
	p Value	<0.0001
VC (l)	Mean	0.13
	95% CI	[0.08; 0.19]
	N	199
	p Value	<0.0001
sRtot (kPa* s)	Mean	-0.11
	95% CI	[-0.21; -0.02]
	N	199
	p Value	0.0169
sRtot (% predicted)	Mean difference	-11.13
	95% CI	[-19.46; -2.80]
	N	199
	p Value	0.0091
Difference between T1-T0		
6MWD (m)	Mean difference	+59.89
	95% CI	[49.09; 70.69]
	N	183
	p Value	<0.0001
FENO (ppb)	Mean difference	-12.74
	95% CI	[-17.38; -8.10]
	N	194
	p Value	<0.0001

FEV₁: forced expiratory volume in 1 s; VC: vital capacity; sRtot: total specific resistance; PR: pulmonary rehabilitation
6MWD: 6-min walk distance; FENO: fractional exhaled nitric oxide.

shown by decreased SGRQ scores. There was a statistically significant reduction in the mean SGRQ score by the end of the 3-week period (10.73 points; $p < 0.0001$) and the score remained lower than at baseline T0 even after 12 months (5.90 points; $p < 0.0001$; Figure 3B). Since a decrease of ≥ 4 points in SGRQ score is considered to be a clinically relevant improvement [23], these data underline that the improved AC after PR makes a difference to the patients and has a positive impact on their lives. A 4-point improvement in SGRQ score

was achieved by 52–68% of patients over the 12-month follow-up period (Figure 3A).

Following sub-group analysis, no influence of co-morbidity on the observed SGRQ scores was detected. Estimates for means and confidence intervals were comparable.

Discussion

As asthma is currently incurable, AC is the main goal when treating patients suffering with asthmatic symptoms. Various cross-sectional studies have shown a high number of patients with poorly controlled asthma (measured by ACT) in Europe. Despite recent progress in drug treatment and medical care, the percentage of German patients with poorly controlled asthma was 62.5% in 2010 [29] implying high treatment costs and high asthma-associated morbidity [30–32]. New approaches to improve AC are urgently required. The ProKAR study demonstrates the potential of a 3-week inpatient PR program for long-term improvement of AC through multidisciplinary treatment combining components such as patient education, physiotherapy, physical exercise, psychosocial support and adequate medication.

We found the following effects of PR on the outcome parameters: the primary outcome AC, as measured using ACT-scores, showed a statistically significant improvement when the patients were discharged and also 3, 6 and 12 months later. A clinically relevant improvement of at least 3 points was seen in 65.3% of patients immediately after PR and it could still be observed in 44.8% of patients one year later.

From all the improvements in short-term outcomes, the improvement in 6MWD was particularly interesting as better physical fitness is known to lead to an improvement in HRQoL for asthma patients [11,12]. In ProKAR the changes in 6MWD at T1 were significant and, in our opinion, also clinically relevant, although the minimal clinically important difference has not yet been defined for asthmatics.

The reduction in the initially raised NO values is driven by many factors and is not primarily due to changes in medication. However the patients' previous medication, optimized before the start of the rehabilitation and only altered in a very few cases, can be more effective when (a) the

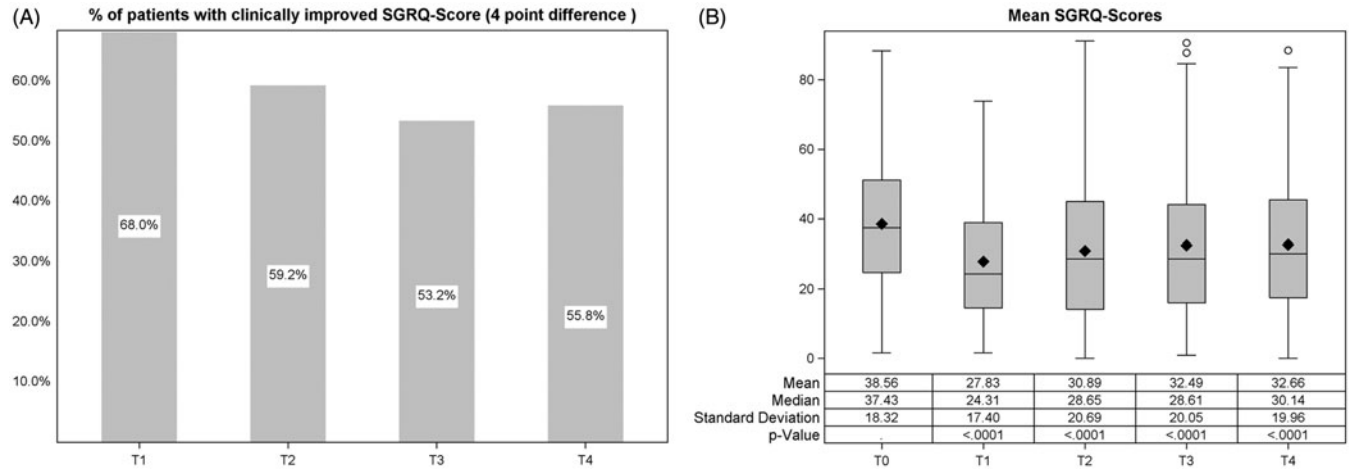


Figure 3. Development of health-related quality of life (HRQoL; (A) the percentage of patients with a clinically relevant improvement at T1–T4 and (B) mean total St. George’s Respiratory Questionnaire (SGRQ) scores.

application of inhaled medication is improved by intensive inhaler device training during the rehabilitation, (b) the medication compliance is improved by intensive patient education in frame of the rehabilitation programme and, trivial but relevant, (c) the medication is always reliably available during the inpatient rehabilitation, i.e. there are no breaks in medication due to waiting for prescriptions or doctor’s appointments. Bad Reichenhall is an established climatic spa area, which means that the local environment is often far better for patients (with or without allergies) than their normal home surroundings, as many patients have workplaces where exposure to allergens, dust, steam and other respiratory tract irritants is commonplace. Additionally, the Bad Reichenhall Clinic is designed for allergy sufferers; the beds, for example, are encased. Concerning the NO values assessed in ProKAR one should bear in mind that there is increasing evidence that physical training per se can reduce the asthmatic inflammation [33].

Remarkably, HRQoL also showed a lasting clinically relevant improvement of at least 4 points in 68% of patients. At the end of the three-week rehabilitation program, the mean total SGRQ had fallen by 10.73 points showing an increase in the HRQoL. Even 12 months after discharge, a reduction of 5.9 points remained, which is categorized as a marked effect [22], clearly above the MCID. Nevertheless the observed marked improvements in AC and HRQoL are not primarily the consequence of the small improvements in lung function. The rehabilitation programme as a whole contributes to the lasting betterment, although improved physical fitness alone, as demonstrated here by the alteration in 6 MWD, could itself induce positive changes in asthma control and quality of life [11,12,34].

Asthmatic patients often present with a wide variety of clinical profiles and comorbidities that interfere with standard asthmatic treatments. All of the ProKAR participants suffered from a combination of somatic and/or mental illnesses in addition to asthma. The individualized combination of standard and optional components included in our PR program may explain the impressive improvement in AC, despite the heterogeneity of the patients. It is possible that the PR program resulted in improvements to other symptoms that also

contributed to the increased HRQoL. This, however, is beyond the scope of this investigation. Nevertheless, we performed sub-group analysis of patients with various categories of co-morbidity, which showed that all groups of patients benefited equally from PR, regardless of their co-morbidities.

The ProKAR study has certain limitations. Firstly, it was a prospective observational study and not a randomized controlled study for the following reasons: in Germany, a patient assigned to a rehabilitation program has a legal right to this treatment and cannot be assigned to a “placebo group”. In addition, the health insurance providers promote the participation in rehabilitation programs as essential for the successful control of asthma symptoms. A patient’s consent to be placed in a control- or placebo group does not have priority over their contractual relationship with the health insurance provider. Secondly, a selective group of asthmatics participated in the ProKAR study: (1) they suffered with severe and recurrent asthma symptoms, which could not be controlled by outpatient medical treatment and which had serious consequences for their daily life and ability to work, and (2) they had undergone a long selection process to be admitted for rehabilitation. Additionally, the ProKAR project was conducted in a single-centre setting, meaning that the results cannot automatically be generalized to all inpatient PR centers, even though Bad Reichenhall is one of the largest of such centers in Germany.

As a complete program of pulmonary rehabilitation was investigated in this study, effects cannot be ascribed to individual components. It is, however, important to note that the patients were already receiving adequate medication before the start of the rehabilitation program. The optimisation of pharmacotherapy during this program is therefore unlikely to have had a major effect on the outcome. Improved compliance or training in correct inhalation techniques during the patient education may, however, contribute to the positive results, in combination with the other components of the rehabilitation program and changes in the patients’ usual daily routine, e.g. the absence of work-related stress and strains and a beneficial environment.

When considering the relevant strengths of ProKAR, we would emphasize (1) the very well-defined patient population

of more than 200 consecutive participants with a diagnosis of bronchial asthma confirmed by a specialist at admission, which was (2) assessed prospectively over the course of a whole year. In addition, we would underline that (3) the study reflects a real-life situation in a large pulmonary rehabilitation centre. Furthermore, the high response rates to the questionnaires should be noted, which remained at 73% even after one year and therefore reflect the reality of the clinical development of asthmatics over one year after discharge from PR in the general study population. The degree to which the 17%, 12% and 27% of non-responders at T2-T4 influence the results remains speculation.

Further analysis of the uptake of the optional components of the PR is planned, with the use of multifactorial regression analysis to analyse the contributions of these modules to the effects of the whole program.

In light of the high numbers of uncontrolled asthmatics, it is important to optimise treatment for the maximum number of patients. With the aim of finding clear inclusion criteria for PR referrals and choices of appropriate PR components, we are therefore currently planning a randomized assessment of PR using a type of wait-list study.

Conclusions

The present study demonstrates that a multidisciplinary 3-week inpatient PR program tailored to each patient's clinical needs may significantly increase the chances of achieving and maintaining good AC for at least one year, regardless of their co-morbidity. The assessed PR program improved exercise performance and had slight positive effects on pulmonary function, leading to a better quality of life. The empowering psychosocial and educational dimensions of this program allowed patients to resume control of their lives by optimizing their treatment for a long time after their discharge.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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