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The Effect of Pulmonary Rehabilitation in Mountain Environment on Exercise Capacity and Quality of Life in Patients with Chronic Obstructive Pulmonary Disease (COPD) and Chronic Bronchitis

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Background: We aimed to test the effectiveness of the pulmonary rehabilitation in a mountain environment on the pulmonary function, physical performance, dyspnea, affective factors, and quality of life (QoL) in patients with chronic obstructive pulmonary disease (COPD) and chronic bronchitis (CB), as well as to determine predictors of clinical improvement.





Material/Methods: 128 consecutive patients (90 diagnosed with COPD and 38 diagnosed with CB) underwent comprehensive pulmonary rehabilitation for a duration of 3 weeks in one of 3 mountain health resorts in the High Tatras. The examination included spirometry (FEV₁ and FEV₁/FVC), 6-minute walk test (6MWT), Borg scale of dyspnea, and assessment of depression (Zung score), anxiety (Beck score), and QoL using the SF-36 scales.

Results: After the study intervention, all patients in both monitored groups demonstrated significant improvements in objective measurements in which large treatment effect was achieved (for FEV₁ $\eta^2=0.218$, for 6MWT $\eta^2=0.771$). Similarly, in subjective measurements a large effect was achieved (for the Beck score: $\eta^2=0.599$, for the Zung score: $\eta^2=0.536$). QoL improved after the intervention in all the monitored SF-36 scales in both groups ($P<0.001$ for all). In patients with COPD, the improvement of exercise capacity was positively correlated with baseline 6MWT and FEV₁, and negatively with the Beck anxiety score and the Borg dyspnea score, whereas, only improvement in the mental summary component of QoL was negatively correlated with baseline 6MWT and FEV₁ ($P<0.05$ for all).

Conclusions: Rehabilitation in a mountain environment has proven to be effective in both the reported diagnoses of COPD and CB. Improvements in both functional and subjective indicators were observed. These findings support the use of this treatment modality.

MeSH Keywords: **Bronchitis, Chronic • Climatotherapy • Pulmonary Disease, Chronic Obstructive • Quality of Life**

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Background

Worldwide, chronic obstructive pulmonary disease (COPD) is the third leading cause of death. According to estimates from the Global Burden of Disease Study, COPD was prevalent in more than 300 million people in 2013. The disease burden and its financial impact is predicted to increase, mainly due to population aging. Several studies have reported on the prevalence of COPD. In European adult populations over 40 years of age, the prevalence of COPD ranges between 15% and 20% [1].

In 2015 in Slovakia, according to the National Health Information Center, there were 83 341 followed patients with COPD (1 535.9/100 000 inhabitants) and 24 817 patients with chronic bronchitis (CB) [2].

According to ATS/ERS (American Thoracic Society/European Respiratory Society), pulmonary rehabilitation is a multidisciplinary and comprehensive intervention for patients with chronic lung diseases in which symptoms predominate and often restrict daily activities. The stabilizing or reversing of the systemic manifestations of the disease are part of the individual patient's treatment and are designed to optimize their functional status, improve participation in physical and social activities, improve quality of life (QoL), and reduce health care costs [3]. Nici et al. [4] report that according to the ATS/ERS, pulmonary rehabilitation is an integral part of the clinical management and the maintenance of the health of patients with chronic pulmonary disease who are experiencing symptoms or whose functions are reduced despite standard medical treatment.

Several studies have indicated a worsening in QoL due to the occurrence of dyspnea, anxiety, and depression, which are often present in COPD patients and associated with poor physical condition, functional impairment, and comorbidities [5,6]. The incidence of depression ranges from 7% to 80% and anxiety from 2% to 80% in patients with COPD [7]. Therefore, according to the study by Cullen et al. [8], early screening is necessary because higher levels of anxiety and depression may lead to poorer results after pulmonary rehabilitation (PR) in 6MWT (6-minute walk test). The presence of these symptoms results in a vicious circle resulting in deconditioning and inactivity, which are key predictors of mortality in COPD patients [9,10]. The key intervention in these pathomechanisms is considered to be the pulmonary rehabilitation treatment [11].

Health Resort Medicine and Climatology as a separate medical unit is not fully recognized internationally partially due to a lack of scientific evidence, the fact that Health Resort Medicine and Climatology is not used in all countries, and that it is focused only on independent methods that do not have a comprehensive concept. Other reservations are related to the fact

that this treatment can only be performed in a specific environment [12]. Eberlein et al. [13,14] recognized the influence of the Alpine Mountain Climate on allergic diseases and COPD. The benefits of the Health Resort Medicine and Climatology are therefore still under discussion [14].

Health Resort Medicine includes "all medical activities originated and derived in health resorts based on scientific evidence aiming at health promotion, prevention, therapy and rehabilitation". Core elements of interventions in health resorts are balneotherapy, hydrotherapy, and climatotherapy [12]. Climatotherapy involves the use of climatic conditions in the treatment of chronic diseases. Mountain and sea climates are used to treat chronic pulmonary diseases [13]. Climatotherapy is considered a part of the comprehensive treatment of respiratory diseases in many European countries, including Slovakia [15,16]. The tradition of Slovak climatotherapy is directly linked to the treatment of chronic pulmonary diseases in the Alps, i.e., high altitude climate therapy (HACT, also known as "alpine" therapy). A meta-analysis of asthma climatotherapy (i.e., HACT) that included studies from 1972 to 2015 concluded that climatotherapy may be effective in improving pulmonary function, however, the authors highlighted the need of further research [15,17]. The climatotherapy of pulmonary diseases in the High Tatras (Slovakia) was introduced in the 19th century by Dr. Szontag. According to climatic stratification [18], the territory of the High Tatras is integrated into an area with very cold temperatures and cold mountain climate. Health resorts in which we provided the climatotherapy-rehabilitation intervention were included in the category of Stimulation Level 1, which has moderate stimulating climatic effects on the human body as categorized by Climatic Classification of Altitudes according to the Physical-Meteorological Observatory in Davos and the Swiss Meteorological Institute [19]. We assume that knowledge from Slovakia could be applicable in other regions as well.

The objective of this study was to test the following hypotheses: 1) whether pulmonary rehabilitation in a mountain environment (i.e., climatotherapy-rehabilitation) is effective in improving pulmonary function, physical performance, dyspnea, affective factors (anxiety, depression), and QoL in patients with COPD and CB; 2) to determine the degree of the improvement, depending on the diagnosis; 3) to analyze correlations between baseline measures of physical and mental functioning status and improvement in the exercise capacity; and 4) to analyze correlations between baseline measures of physical functioning status and improvements in QoL.

Material and Methods

This study involved patients with COPD diagnosis and patients with CB diagnosis who were referred for pulmonary

rehabilitation in a mountain environment. Our prospective study, which was conducted from August 2014 to December 2014, involved 128 consecutive patients, with 90 of these patients diagnosed with COPD and 38 of these patients diagnosed with CB. The diagnosis of COPD was based on postbronchodilator forced expiratory volume (FEV) in 1 sec to forced vital capacity (FVC) ratio (FEV₁/FVC) being <0.7 [11]. The diagnosis of CB was based on the presence of chronic symptoms (cough, sputum, and/or dyspnea) and normal spirometry, according to the previously published definition used separate stage 0 for COPD [20]. Patients with acute exacerbations, respiratory insufficiency, and coronary artery disease (all stages according to the New York Heart Association), and patients with a history of previous myocardial infarction or stroke were excluded. Exclusion criteria also included non-cooperation or non-consent of the patient. The research was approved by the ethics committee of the treatment facility. All patients signed an informed consent.

Intervention

All patients underwent comprehensive pulmonary rehabilitation in one of 3 health resorts in the High Tatras, which form a part of the Carpathian Mountains.

Characteristics of treatment

The research itself was carried out in 3 spa facilities located in the Slovak part of the High Tatras: in the Sanatorium Tatranská Kotlina (760 a.s.l.), the Sanatorium Dr. Guhr Tatranská Polianka (1067 a.s.l.), and the Nová Polianka Specialized Institute for Pulmonary Diseases (1040 a.s.l.). The health resorts are located at an altitude between 760 and 1067 meters above sea level, which corresponds with a mountain altitude. The climatotherapy-rehabilitation treatment lasted for 3 weeks and included a standard climatotherapy-rehabilitation set of procedures. This set consisted of exercise training set up according to international recommendations [3,21], moreover, it also included strength training, respiratory physiotherapy, physical therapy, hydrotherapy, and climatotherapy. Patients completed the daily program 5 days a week. Exercise prescription was based on the outcome of initial exercise assessment and was increased throughout the program as tolerated (see Supplementary Table 1 for details).

The overall training intensity was set at a dyspnea rating scale of 3 according to the Borg dyspnea scale.

Programs were multidisciplinary with an educational component covering issues including exercise (which was recommended during the program and was to continue after its completion), medication use, diet, and coping strategies.

Measurements

Patients were examined at the beginning and end of the climatotherapy-rehabilitation intervention. The examination included spirometry (FEV₁ and FEV₁/FVC), 6MWT, Borg scale of dyspnea, depression, anxiety, and QoL assessment.

We used the 6MWT to assess exercise capacity. This test has been broadly used to assess the effects of treatment for people with a variety of cardiovascular and lung diseases, including COPD. The 6MWT was performed indoors along the corridor (25 meters) in accordance with international recommendations [22]. The subjective dyspnea score was evaluated using a modified scale according to Borg [23,24]. We evaluated QoL with the general QoL questionnaire SF-36. It consists of 36 items and is divided into 8 subscales: physical functioning (PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social functioning (SF), role emotional (RE), mental health (MH); 2 summary scales (the physical component summary (PCS) and the mental component summary (MCS)). The SF-36 overall QoL index is used in the evaluation of QoL (Perceived Health Status or PHS) [25,26].

The Beck Anxiety Inventory was used to evaluate anxiety. The overall score ranges from 0 to 63, and Zung's self-assessment depression scale, resulting in the SDS index (SDS – Zung's Self-Rating Depression Scale) [27,28].

The minimal clinically important difference (MCID) has been used to characterize patients benefiting from pulmonary rehabilitation [29]. This parameter allows the comparison of results between programs that have different starting clinical measurements. The MCID for different test variables was defined according to cited publications. For the 6MWT it is defined as an increase of more than 30 meters [30]. The MCID of the SF-36 QoL in COPD was defined according to Wyrwich et al. [31]. The MCID was set to 10 points for summary scores PCS and MCS of the SF-36 [32].

Statistical analysis

The evaluation was performed by comparing 2 groups of patients (patients with COPD and patients with CB) before initiation of the treatment with baseline measurements, and again after the intervention of 3 weeks of pulmonary rehabilitation in a mountain environment.

Descriptive statistics were used for data processing; baseline differences between COPD and CB were evaluated by an unpaired *t*-test, and before and after intervention with a paired *t*-test. The effectiveness of the 3-week intervention program was evaluated using the GLM (General Linear Model) test through the ANOVA mixed design. Partial Eta² (η^2) was used

to measure the effect size. Interpretation of the effect size according to Cohen [33] for the ANOVA analysis was 0.00–0.003 as no effect; 0.010–0.039 as small effect; 0.060–0.110 as intermediate effect; and more than 0.140 as large effect. Pearson's correlation coefficients were calculated between improvement in exercise capacity (distance in the 6MWT) after the pulmonary rehabilitation in COPD patients and in CB patients, and baseline measurements of physical and mental functioning status, with subsequent partial correlation analyses controlling for age, gender, and body mass index (BMI); the same procedure was also applied between improvements in the SF-36 QoL summary scales and baseline values of FEV₁ and 6MWT (all controlling for age, gender, and BMI).

The statistical analysis was performed using the IBM SPSS 19 software. Data are presented as mean \pm 1 standard deviation (SD) or as percentages. The level of statistical significance was set at $P < 0.05$.

Results

In total, 90 patients with COPD and 38 patients with CB underwent complex pulmonary rehabilitation in the health resorts in the High Tatras. The COPD group consisted of 64 men (71%) and 26 women (29%) with an average age of 65.7 ± 11.9 years; the group with CB consisted of 23 men (61%) and 15 women (39%) with an average age of 60.2 ± 8.9 years. According to GOLD (Global Initiative for Chronic Obstructive Lung Disease) [11], patients with COPD were classified according to the severity of decline in stage in pulmonary function as follows: 14 patients (16%) at stage I, 45 patients (50%) at stage II, 27 patients (30%) at stage III, and 4 patients (4%) at stage IV. In the personal interview, we also recorded whether respondents smoke or smoked in the past and how many cigarettes a day. Among respondents with COPD, there were 46 (51%) non-smokers, 34 (38%) ex-smokers, and 10 (11%) current smokers. Among respondents with CB, there were 17 (45%) non-smokers, 15 (39%) ex-smokers, and 6 (16%) current smokers. There was no difference in gender between the 2 groups ($P = 0.244$). Table 1 displays baseline characteristics between the 2 groups of studied patients according to diagnosis. COPD patients were older, had worse pulmonary function, achieved a lower distance in the 6MWT, and experienced more severe dyspnea both at rest and after a 6MWT compared to CB patients. When comparing the monitored QoL domains, COPD patients had lower baseline scores, and thus had worse prospects in GH, PF, RP, and PCS than CB patients.

The effect of the pulmonary rehabilitation in patients with CB and COPD

After completing the intervention of climatotherapy-rehabilitation treatment, all patients in both monitored groups

demonstrated statistically significant improvements in objective measurements, i.e., FEV₁ and 6MWT ($P < 0.001$ for both parameters) and for which a large treatment effect was achieved (for FEV₁ $\eta^2 = 0.218$, for 6MWT $\eta^2 = 0.771$). In subjective measurements, there was a statistically significant improvement in the Beck anxiety score, as well as in the Zung depression score ($P < 0.001$ for both parameters) with large treatment effects observed (for the Beck score: $\eta^2 = 0.599$, for the Zung score: $\eta^2 = 0.536$). In anxiety, the interaction between the intervention at the defined time and diagnosis was statistically significant ($P = 0.040$): patients with CB showed larger improvement compared to patients with COPD. In the case of dyspnea, we noticed a small intervention effect in the improvement of dyspnea at rest ($\eta^2 = 0.016$), which did not achieve statistical significance ($P = 0.153$) for the entire cohort; we also noticed intermediate effect of treatment on the improvement of dyspnea after completing the 6MWT ($\eta^2 = 0.066$, $P = 0.003$) in all patients. However, there was a statistically significant interaction between intervention at the defined time and diagnosis, in which dyspnea before and after the walk ($P = 0.004$ and $P = 0.001$, respectively) was reduced by intervention in COPD patients, whereas in CB patients, it was not influenced (Table 2).

In the QoL measurements, according to SF-36, there was a statistically significant improvement after the intervention in all the monitored subscales and summative scores in both CB patients and COPD patients ($P < 0.001$ for all, Table 3). We observed a large effect of the intervention on the subscales of the GH, PF, RP, BP, VT, SF, MH, and intermediate effect in RE (η^2 Table 3). In the summary dimensions, a large effect was achieved for all the dimensions of PCS, MCS, and PHS (η^2 Table 3). The interactions between intervention at the defined time and diagnosis in none of the monitored subscales and summative scores was statistically significant (Table 3).

Correlation analysis between improvement in exercise capacity and baseline measures of physical and mental functioning status

A clinically important improvement in the distance achieved in the 6MWT (an increase of at least 30 meters in length) was achieved by 20 patients with CB (52.6%) and 33 patients with COPD (36.7%).

In patients with COPD, the improvement of exercise capacity (i.e., an increase in the distance walked in the 6MWT) was positively correlated with baseline 6MWT and FEV₁ values, and negatively correlated with the Beck anxiety score and the Borg dyspnea score both before and after exercise. All observed correlations remained statistically significant after controlling for age, gender, and BMI. In patients with CB, only an inverse relationship with the Beck anxiety score remained statistically significant after controlling for age, gender, and BMI (Table 4).

Table 1. Comparison of baseline characteristics between CB and COPD patients.

Parameters	Group	Mean (SD)	t	p
BMI	COPD	27.0±5.0	-1.146	0.254
	CB	28.2±6.9		
Age (years)	COPD	65.7±11.9	2.589	0.011
	CB	60.2±8.9		
FEV1 (% predicted)	COPD	61.0±22.6	-5.150	0.000
	CB	82.4±18.5		
FEV1 (ml)	COPD	1626±574	-6.120	0.000
	CB	2323±622		
FEV1/FVC (%)	COPD	52.6±11.0	-14.607	0.000
	CB	80.1±5.6		
Beck score	COPD	14.8±8.3	-2.770	0.006
	CB	19.8±11.7		
Zung score	COPD	53.2±10.2	1.424	0.157
	CB	50.1±12.5		
6 MWT (m)	COPD	258±108	-4.484	0.000
	CB	346±82		
Borg score before walking	COPD	1.34±1.13	2.221	0.028
	CB	0.87±1.04		
Borg score after walking	COPD	3.64±1.90	3.039	0.003
	CB	2.60±1.39		
General Health	COPD	39.3±17.6	-2.158	0.033
	CB	47.2±21.7		
Physical Functioning	COPD	44.7±24.1	-2.010	0.047
	CB	54.2±25.2		
Role Physical	COPD	28.3±31.8	-2.913	0.004
	CB	47.4±38.0		
Bodily Pain	COPD	56.6±24.1	0.097	0.923
	CB	56.1±21.4		
Vitality	COPD	57.6±18.2	0.460	0.646
	CB	55.9±20.8		
Social Functioning	COPD	62.9±23.5	0.680	0.498
	CB	59.9±22.4		
Role Emotional	COPD	42.6±39.7	-0.968	0.335
	CB	50.0±39.3		
Mental Health	COPD	62.2±20.7	0.261	0.794
	CB	61.2±21.8		
PCS	COPD	42.2±17.4	-2.505	0.014
	CB	51.2±21.1		
MCS	COPD	56.3±18.4	-0.107	0.915
	CB	56.7±21.6		
Perceived health status	COPD	49.3±15.8	-1.409	0.161
	CB	54.0±20.3		

PCS – physical component summary; MCS – mental component summary.

Table 2. The average values and statistical comparison of CB and COPD patients before and after the 3-week pulmonary rehabilitation in objective and subjective parameters.

Parameters	Group	Average values ±SD before PR	Average values ±SD after PR	Comparison before and after treatment				Interaction		
				F value	P Couple	η ²	Interpretation	F value	P between	η ²
FEV ₁ (% predicted)	CB	82.4±18.5	86.2±19.4	35.038	0.000	0.218	Large effect	0.137	0.712	0.001
	COPD	61.0±22.6	64.3±22.9							
FEV1 (ml)	CB	2323±622	2439±691	35.038	0.000	0.218	Large effect	0.137	0.712	0.001
	COPD	1626±574	1710±577							
6MWT (m)	CB	346±82	371±85	423.413	0.000	0.771	Large effect	0.132	0.717	0.001
	COPD	258±108	282±112							
Beck score	CB	19.8±11.7	12.3±6.6	188.219	0.000	0.599	Large effect	4.327	0.040	0.033
	COPD	14.8±8.3	9.3±5.9							
Zung score	CB	50.1±12.5	45.0±9.7	139.745	0.000	0.536	Large effect	0.311	0.578	0.003
	COPD	53.2±10.2	47.6±7.7							
Borg score before walking	CB	0.87±1.04	0.95±1.09	2.065	0.153	0.016	Small effect	8.448	0.004	0.063
	COPD	1.34±1.13	1.11±0.97							
Borg score after walking	CB	2.60±1.37	2.63±1.40	8.922	0.003	0.066	Intermediate effect	10.82	0.001	0.079
	COPD	3.64±1.90	3.10±1.45							

PR – pulmonary rehabilitation.

Correlation analysis between improvements in the SF-36 QoL and baseline measures of physical functioning status (FEV₁ and 6MWD)

An improvement in the MCS summary score was negatively correlated with the baseline distance achieved during the 6MWT after controlling for age, gender, and BMI in patients with COPD (Table 5).

Discussion

Pulmonary rehabilitation is an important aspect of COPD management to improve symptoms, physical activity, daily life, social functions, and QoL. According to the study by Sundh et al. [34], many patients do not receive rehabilitation treatment, mainly due to insufficient use of rehabilitation options. In our opinion, one of the possibilities for increasing the availability of pulmonary rehabilitation is the use of available facilities for climato-therapy. There is still a lack of research focused on mountain climate therapy. Eberlein et al. [13] found that rehabilitation treatment at specialized facilities in the Bavarian Mountains had a beneficial effect on patients with asthma and COPD, with the potential to improve pulmonary function (FEV₁) and 6MWT. The effectiveness of health resort therapy and climate therapy has been discussed at the international level [12]. In many European countries, health resort therapy is fully recognized

as a medical field. Since discussions are still ongoing, we have decided to verify the effects of climatotherapy-rehabilitation treatment on parameters of physical functioning, symptoms, and QoL in patients with chronic non-allergic pulmonary disease in mountain resorts of the High Tatras.

After completing the pulmonary rehabilitation in a mountain environment in both CB patients and COPD patients, we observed improvements in the majority of the monitored objective and subjective functional parameters except for dyspnea at rest, and improvements in the scores were observed for all the monitored SF-36 QoL dimensions. Of note, statistically significant differences were found between the subgroups of patients according to the diagnosis in the baseline descriptive parameters: compared to patients with CB, patients with COPD had by definition worse pulmonary function and performance in the 6MWT, higher intensity of perceived anxiety, as well as dyspnea before and after walking, and had a worse score in the subscales of QoL of GH, PF, RP, and summary scores PCS. To take these differences into account, the mixed design ANOVA statistical model was used to describe the potentially different intervention effects between the subgroups according to the diagnosis (interaction between intervention at the defined time and diagnosis), according to which there was a greater intervention effect on the dyspnea COPD patients before walking exercise (P=0.004 versus CB) and after walking exercise (P=0.001 versus CB). On the contrary, patients with

Table 3. The average values and statistical comparison of CB and COPD patients before and after the 3-week pulmonary rehabilitation in SF 36 QoL.

SF 36 score (subscales and summary scales)	Group	Average values \pm SD before PR	Average values \pm SD after PR	Comparison before and after treatment				Interaction		
				F value	P Couple	η^2	Interpretation	F value	P between	η^2
General Health	CB	47.2 \pm 21.7	57.8 \pm 15.0	125.718	0.000	0.499	Large effect	0.812	0.369	0.006
	COPD	39.3 \pm 17.6	51.7 \pm 14.6							
Physical Functioning	CB	54.2 \pm 25.2	62.9 \pm 24.1	86.059	0.000	0.406	Large effect	0.041	0.840	0.000
	COPD	44.7 \pm 24.1	53.8 \pm 21.3							
Role Physical	CB	47.4 \pm 38.0	57.2 \pm 33.8	30.842	0.000	0.197	Large effect	0.509	0.477	0.004
	COPD	28.3 \pm 31.8	41.1 \pm 32.3							
Bodily Pain	CB	56.1 \pm 21.4	73.4 \pm 16.1	191.637	0.000	0.603	Large effect	1.758	0.187	0.014
	COPD	56.6 \pm 24.1	70.8 \pm 19.1							
Vitality	CB	55.9 \pm 20.8	80.1 \pm 20.8	487.434	0.000	0.795	Large effect	0.657	0.419	0.005
	COPD	57.6 \pm 18.2	83.7 \pm 19.8							
Social Functioning	CB	59.9 \pm 22.4	73.7 \pm 19.2	79.484	0.000	0.387	Large effect	3.253	0.074	0.025
	COPD	62.9 \pm 23.5	72.1 \pm 21.5							
Role Emotional	CB	50.0 \pm 39.3	58.8 \pm 39.1	18.304	0.000	0.127	Intermediate effect	0.186	0.667	0.001
	COPD	42.6 \pm 39.7	53.3 \pm 36.3							
Mental Health	CB	61.2 \pm 21.8	83.0 \pm 19.2	417.734	0.000	0.768	Large effect	0.030	0.863	0.000
	COPD	62.2 \pm 20.7	83.6 \pm 19.9							
PCS	CB	51.2 \pm 21.1	62.8 \pm 17.2	190.968	0.000	0.602	Large effect	0.095	0.759	0.001
	COPD	42.2 \pm 17.4	54.4 \pm 16.1							
MCS	CB	56.7 \pm 21.6	73.9 \pm 18.7	349.117	0.000	0.735	Large effect	0.027	0.869	0.000
	COPD	56.3 \pm 18.4	73.2 \pm 18.4							
Perceived Health	CB	54.0 \pm 20.3	68.4 \pm 17.3	336.784	0.000	0.728	Large effect	0.005	0.942	0.000
	COPD	49.3 \pm 15.8	63.8 \pm 15.7							

PCS – physical component summary; MCS – mental component summary; PR – pulmonary rehabilitation.

CB achieve somewhat greater benefits in reducing anxiety ($P=0.040$ versus COPD). In the remaining monitored parameters, the improvements were comparable between the subgroups according to the diagnosis.

In the study by Eberlein et al. [13], similar to our study, improvements were observed in spirometry parameters (FEV_1) and exercise capacity (6MWT) but only observed in some domains (RP, BP, PH, SF, and RE) in the SF-36 QoL. However, this aforementioned study was focused largely on patients diagnosed with bronchial asthma.

Karagiannidis et al. [35] reported that climatic treatment improved clinical symptoms of asthma and reduced local inflammation of the respiratory tract. In addition to the mountain climate, Dramsdahl [36] presented the use of the Dead Sea climato-therapy

as an integrated adjunct therapeutic modality in a complex pulmonary rehabilitation program for patients with COPD, asthma, and cystic fibrosis, which improved clinical parameters and QoL.

In a recent meta-analysis, Vinnikov et al. [15] evaluated the effectiveness of the mountain climate on the asthma of 907 patients. In 93% of patients, high-altitude climatotherapy was found to be an effective intervention to improve pulmonary functional parameters. In the aforementioned mountain climate studies, more attention was paid to patients with asthma and allergic diseases of the respiratory system, whereas in our research we focused on patients with non-allergic chronic inflammatory diseases of the respiratory tract. In addition to the objective parameters and QoL, in our study we also studied the effect of treatment on subjective perceived dyspnea, anxiety, and depression in COPD patients and CB patients.

Table 4. Pearson’s and partial correlation analysis between improvement in exercise capacity (distance in the 6MWT) after the pulmonary rehabilitation in COPD and CB patients and baseline measures of physical and mental functioning status.

Parameter at baseline		Δ 6MWT			
		R		Partial correlation	
6MWT (m)	COPD	0.265	(0.012)	0.241	(0.029)
	CB	0.318	(0.052)	0.354	(0.037)
FEV1	COPD	0.448	(0.000)	0.420	(0.000)
	CB	0.076	(0.651)	-0.050	(0.774)
Beck	COPD	-0.289	(0.006)	-0.295	(0.007)
	CB	-0.354	(0.029)	-0.456	(0.006)
Zung	COPD	-0.046	(0.675)	-0.071	(0.524)
	CB	-0.098	(0.558)	-0.087	(0.621)
Borg before walking	COPD	-0.254	(0.016)	-0.296	(0.007)
	CB	-0.327	(0.045)	-0.300	(0.080)
Borg after walking	COPD	-0.278	(0.008)	-0.316	(0.004)
	CB	-0.341	(0.036)	-0.332	(0.052)

R – Pearson’s correlation coefficient; Bold-numbers are statistically significant results with p<0.05 (p value in parentheses); Partial correlation adjusted for age, gender, BMI.

Table 5. Pearson’s and partial correlation analysis between improvement in the SF 36 quality of life summary scales after the pulmonary rehabilitation in COPD and CB patients and baseline values of FEV1 and 6MWT.

SF 36 score		FEV ₁				6MWT			
		R		Partial correlation		R		Partial correlation	
Δ PCS	COPD	0.146	(0.170)	0.079	(0.466)	-0.130	(0.222)	-0.132	(0.223)
	CB	-0.118	(0.481)	-0.148	(0.396)	-0.100	(0.552)	-0.161	(0.356)
Δ MCS	COPD	-0.050	(0.642)	-0.083	(0.443)	-0.254	(0.016)	-0.248	(0.020)
	CB	0.047	(0.779)	-0.025	(0.888)	-0.062	(0.712)	-0.160	(0.359)

R – Pearson’s correlation coefficient; Bold-numbers are statistically significant results with p<0.05 (p value in parentheses); Partial correlation adjusted for age, gender, BMI.

Dyspnea is a major symptom of COPD, causing significant reductions in performance and QoL and is often associated with comorbid anxiety and depression. Dyspnea is usually experienced as highly aversive and threatening [37]. As a result, many patients avoid situations related with dyspnea, which is in mainly physical activity, leading to progressive decline of physical condition, ultimately increasing dyspnea in low activity levels and contributing to the progression of disease [7]. Moreover, the loss of control over the disease itself and the loss of ability to engage in personal and social activities are frustrating and anxiety-inducing. The detection and recognition of these symptoms is of the utmost importance because they are related to the progression of disease and they may be

approached by medical treatment and rehabilitation [38–40]. The meta-analysis of McCarthy et al. [9] demonstrated that PR relieved dyspnea and fatigue, improved emotional function, and enhanced the sense of control that individuals had over their condition. These improvements were moderately large and clinically significant. The results of our work extend this knowledge even further: pulmonary rehabilitation is an effective tool for influencing dyspnea in COPD patients, with the observed improvement being greater than in patients with CB and normal pulmonary function.

In clinical practice, another frequently used tool for assessing the effect of intervention is the MCID concept, which has

recently been used to evaluate improvement in exercise capacity and QoL after pulmonary rehabilitation. Boutou et al. [29] and McCarthy et al. [9] presented the results of randomized controlled trials according to which the MCID for 6MWT is 30 meters. Based on this value, in our study more than half of patients with COPD and more than one-third of CB patients (who had better baseline values) achieved a clinically important improvement in the 6MWT after completing the climatotherapy-rehabilitation treatment. The work by Boutou et al. [29] demonstrated an improvement in exercise capacity in 68% of COPD patients from those who completed rehabilitation, which is a higher rate compared to our results, but in their work only 57% of patients completed the rehabilitation treatment and, moreover, their research did not include patients with CB.

In patients with both diagnoses, the intensity of anxiety was negatively correlated with achieved improvements in exercise capacity. In a population-based study by Leivseth et al. [41] found that anxiety was present in 15.6% of patients with CB, anxiety and dyspnea were related to each other, and dyspnea may affect anxiety or vice versa. In the study by Amiri et al. [42] in which the prevalence of anxiety in COPD patients was evaluated, values ranged considerably from 2% to 96%. In patients with COPD and anxiety, the health outcomes were worse, including the exercise capacity (6MWT) [43] and patients had a higher number of exacerbations [44]. In our group, 72.2% of patients with COPD and 84.2% of patients with CB suffered from anxiety. Depression often occurs together with anxiety, and both co-morbidities are usually evaluated at the same time. There are various approaches for the treatment of depression and anxiety. Comprehensive PR procedures that included exercise training with or without psychological and medical interventions have been shown to have the greatest effect on exercise capacity, anxiety, depression, and dyspnea, while at the same time positively affecting the QoL [38–40].

Within the subgroup of COPD patients, baseline parameters were lower degree of bronchial obstruction, lower perceived intensity of dyspnea at rest and after exertion, and a better baseline performance in the 6MWT identified as positively correlated with the achieved improvements in exercise capacity. On the contrary, the predictor of the achieved MCID in the exercise capacity in the study by Boutou et al. [29] was a lower baseline 6MWT level, nevertheless the patients in their study were older and had worse spirometric features, more pronounced dyspnea, and more severe symptoms.

Many studies have reported that improving the QoL should be considered the primary result of pulmonary rehabilitation [9,29,45,46]. Interestingly, in our study, we observed that lower baseline distance in the 6MWT was related to an improvement in the MCS summary score in patients with COPD. Predictors of the MCID in improving the QoL as assessed by the CAT

(COPD Assessment Test) in the study by Boutou et al. [29] were younger age and fewer symptoms. Notwithstanding, their study used a different questionnaire than we used in our study.

Study strengths and limitations

As one of the strengths of this research, we consider evaluating the effect of pulmonary rehabilitation treatment in a mountain environment. We have studied the additive effect of pulmonary rehabilitation and climatotherapy, while many of the cited studies [9,29,47] only followed the effect of pulmonary rehabilitation without studying the effect of climatotherapy.

This effect was monitored in 3 High Tatras mountain resorts within the same climatic zone and accordingly with the same level of bioclimatic stimulation. Location of health resorts at 3 different altitude levels ranging between 760 and 1067 meters above sea level could be viewed as a limitation of the study. Nevertheless, in our study we adhered to the Swiss climatic classification of altitudes according to the Physical-Meteorological Observatory in Davos and the Swiss Meteorological Institute [19] based on altitude treatment stimulation intensity. This classification has been used in several countries in Europe. According to this classification, all mountain health resorts engaged in our study were located within the Level 1 of Stimulation ranging from 500–1100 meters above sea level [48] and thus our study group can be viewed as homogenous in terms of delivered intervention. Notwithstanding, this classification also has some disadvantages as it does not take into account all the local climatic specifics or the individual patient needs.

Another strength of our study was the implementation of a wide range of objective and subjective functional parameters along with a multidimensional evaluation of perceived QoL before and after a defined intervention in a representative set of patients with the 2 most commonly occurring chronic non-allergic inflammatory pulmonary diseases, which in practice are referred for this type of treatment. We used sophisticated statistical models (mixed design ANOVA and multivariate logistic regression models with the implementation of the MCID achievement concept).

Limitations of this study imply the impossibility of separating the effect of rehabilitation procedures from the effect of the mountain climate alone, but this is of less practical significance, because both effects intentionally act together. It is not possible to exclude the referral bias: the fact that patients with milder COPD stages are referred to mountain sanatoriums (in our group two-thirds of the COPD patients had first and second degree of severity of airflow obstruction according to GOLD) [11], so the results of our observations should be interpreted with caution in patients with severe airflow

limitation in COPD (only 4 patients with FEV₁ less than 30% were participants in our study population).

Conclusions

In our study, we demonstrated the effectiveness of the complex climatotherapy-rehabilitation treatment in a mountain environment in patients with CB and COPD, as reflected by the improvements in almost all of the studied subjective and objective parameters. Both groups of patients experienced a statistically important improvement in exercise capacity and a large treatment effect was observed in improving the majority of the dimensions of QoL. Among the monitored groups according to the diagnosis, the effects of the intervention were comparable except for the effect on dyspnea which was greater in favor of patients with COPD, in whom the baseline values were worse. We further found that the intensity of anxiety negatively affected expectable improvements in exercise capacity in both patient groups. Additionally, in the COPD group, patients with better baseline FEV₁ and 6MWT distance as well as with less pre-and post-exercise dyspnea had better prospects for clinically important improvement in exercise capacity.

To summary, the climatotherapy-rehabilitation has been shown to be effective in both reported diagnoses as well as throughout the entire spectrum of functional status, although individual patients may benefit in different ways depending on the diagnosis and disease severity. As the correlation analyses revealed relationships between baseline functional and mental status and achieved improvements in exercise capacity and in QoL, further research is warranted to identify possible predictors of clinically important improvements. In our opinion, this knowledge should serve as a motivation for specialists for patients with lung diseases to become more involved in climate and rehabilitation treatment as part of their comprehensive treatment.

Statement

The research was carried out in 3 health resorts in a mountain environment of the High Tatras, which form a part of the Carpathian Mountains in Sanatorium Tatranská Kotlina, Sanatorium Dr. Guhr Tatranská Polianka and the Nová Polianka Specialized Institute for Pulmonary Diseases.

Conflicts of interest

None.

Supplementary Table

Supplementary Table 1. Rehabilitation protocol for pulmonary patient.

	Mode	Intensity	Protocol	Duration	Frequency, provider
Lower limb 1) endurance training Ground walking	Walking training	80% average speed on 6MWT	Continuous	30 minutes	5 times a week supervised sessions, physiotherapist
	Ground-based	Dyspnoea rating of 3 (moderate)			
2) strength training	Strength training without weights: Squats. Straight leg raise. Step-ups or stair climbing. Sit-to-stand from progressively lower chairs	10 RM (repetition maximum)		10 repetitions (1 set)	5 times a week, physiotherapist
Upper limb 1) endurance training	Exercises	Determine the weight that the patient can only lift 15 times		15 repetitions (1 set)	5 times a week supervised sessions. physiotherapist
	Elastic bands.	Dyspnoea rating of 2 or 3 (slight or moderate)			

	Mode	Intensity	Protocol	Duration	Frequency, provider
2) strength training	Exercises Asking the patient to lift their arms alternately overhead 15 times holding a light weight (e.g. 1–2 kg)	10 RM (repetition maximum)		10 repetitions (1 set)	5 times a week supervised sessions, physiotherapist
Respiratory physiotherapy	Pursed-lip breathing Posture techniques Diaphragmatic breathing, Flutter	Warming up phase 5 min., Breathing techniques 10–15 min., Relaxation exercises 5–10 min.		30 min.	5 times a week supervised sessions, respiratory physiotherapist
Physical therapy	Manual massage or soft tissue techniques			10-15 min	5 times a week, respiratory physiotherapist
Hydrotherapy	Whirlpool (upper or lower limb)			5-10min.	5 times a week
Climatotherapy	3 Health resorts in High Tatras	Stimulation level 1 – with moderate stimulating climatic effects	daily	5 hours	21 days
Educational component	Exercise education Lecture			5-10 min. 60 min.	5 times a week, physiotherapist respiratory physiotherapist once in 3 weeks, physiatrist
Disease education	Lecture	Smoking cessation, nutritional interventions, exercise, and health promotion, oxygen therapy, inhalation techniques		60 min.	once in 3 weeks, physiatrist, physician
Coping strategies	Lecture	Symptom management, psychological interventions, anxiety, depression management		60 min.	Once in 3 weeks, psychologist

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