

Physical inactivity in COPD and increased patient perception of dyspnea

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Objective: To study patients' levels of exercise activity and the clinical characteristics that relate to physical activity and inactivity among patients with chronic obstructive pulmonary disease (COPD).

Methods: A postal questionnaire was administered to 719 patients with COPD in 2010; patients were recruited from the Helsinki and Turku University Central Hospitals in Finland and have been followed since 2005. The questionnaire asked participants about their exercise routines and other daily activities, potential restrictions to exercise, health-related quality of life, and subjective sensations of dyspnea upon exertion.

Results: A total of 50% of the participants reported exercising > 2 times a week throughout the year. The proportion of the exercise inactive patients increased in parallel with disease progression, but the participants exhibited great variation in the degree of activity as well as in sport choices. Year-round activity was better maintained among patients who exercised both indoors and outdoors. Training activity was significantly correlated with patients' reported subjective dyspnea ($r = 0.32$, $P < 0.001$), health-related quality of life ($r = 0.25$, $P < 0.001$), mobility score ($r = 0.37$, $P < 0.001$), and bronchial obstruction ($r = 0.18$, $P < 0.001$). Active patients did not differ from inactive patients in terms of sex, age, smoking status, somatic comorbidities, or body mass index. Irrespective of the level of severity of patients' COPD, the most significant barrier to exercising was the subjective sensation of dyspnea.

Conclusion: When a patient with COPD suffers from dyspnea and does not have regular exercise routines, the patient will most likely benefit from an exercise program tailored to his or her physical capabilities.

Keywords: COPD, physical fitness, exercise training, physical activity, pulmonary rehabilitation

Introduction

Patients with chronic obstructive pulmonary disease (COPD) are reported to be less physically active than both their age- and sex-matched healthy counterparts and patients with other chronic diseases such as rheumatoid arthritis or diabetes.¹⁻⁵ On the other hand, COPD patients who do remain physically active have lower mortality rates, better performance status, and better health-related quality of life (HRQoL).⁶⁻¹⁰ It is poorly understood why a significant proportion of patients with very severe bronchial obstruction can maintain remarkable levels of physical activity, while others start to lose their exercise capacity at early stages of the disease.⁶⁻¹² Medical literature on clinical variables associated with physically inactive COPD patients, and data about their willingness to participate in pulmonary rehabilitation programs is sparse. The types of exercise activities that COPD patients favor are also largely unknown.

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COPD is the only disease associated with consistently rising hospital admission and mortality rates worldwide,^{13,14} which results in significant health care costs. Physical inactivity is recognized as a significant risk factor for the exacerbation of COPD, which, in turn, can accelerate the decline of lung function.^{7–9,15} Pulmonary rehabilitation is shown to be especially effective in preventing the exacerbation of the disease.^{16–18} There is also cumulative evidence that regular exercise improves patients' exercise capacity, symptom tolerance, and HRQoL. Evidence pertaining to the positive effects of pulmonary rehabilitation programs on patient's HRQoL are less abundant.^{19–23}

While the short-term benefits of pulmonary rehabilitation programs are extremely encouraging, more research is needed to assess the long-term results of pulmonary rehabilitation. Previous studies suggest that the positive effects of pulmonary rehabilitation on a patient's exercise capacity might be lost within a year.^{19,20} In order to develop more successful pulmonary rehabilitation programs, our aim in the present study was to improve the understanding of COPD patients' spontaneous exercise routines, the sports they practice, the potential barriers of exercising, and the role of dyspnea in a patient's capacity to exercise. Since the cohort that was examined in this study also displayed very severe stages of the disease, the overall physical activity among COPD patients was further studied by quantifying their daily activities and overall mobility. Our expectation was that COPD patients exercise less than is recommended according to health-promotion strategies, and that the sports in which they are able to participate are limited. We suspected that severe bronchial obstruction, comorbidities, impaired diffusion capacity, and old age would be the risk factors associated with physical inactivity. We also inquired as to whether the study subjects had previously participated in a pulmonary rehabilitation program or received guidance on physical training, and about their interest in participating in a pulmonary rehabilitation program. These COPD patients are well-defined and have been followed since 2005, which allowed us to add several clinical background variables to the analysis.

Materials and methods

Study population

All of the study subjects were identified from the Finnish chronic airway disease cohort.²⁴ The cohort was recruited from the pulmonary clinics of the Helsinki and Turku University Central Hospitals, Finland, from 2005–2007, and their medical records were retrospectively evaluated starting

from the onset of each patient's disease. Smoking-related COPD or chronic bronchitis was verified for 959 patients. All participants provided their informed consent and the researchers were able to collect and analyze the patients' medical records; furthermore, patients also agreed to participate in follow-up studies over the proceeding 10 years. A total of 19 participants withdrew from the study. The annual death rate noted in the cohort was 3.6%. The study was approved by the Ethics Committee of the Hospital District of Helsinki and Uusimaa.

Assessment of physical activity

All surviving and still actively participating COPD patients ($n = 827$) were mailed a questionnaire asking questions about their exercise activities, time spent on daily life activities, and fitness training between March and April 2010 (a translated version of the questionnaire is available in the Supplementary material [Table S1]). Following one reminder, the overall response rate was 87% ($n = 719$). Exercise activity during winter and the rest of the year were inquired about separately (Q1B and Q1A, respectively) by the question: "How often do you exercise at least half an hour at a time with the intensity which makes you at least mildly short of breath and perspire?" Questions Q2 and Q3 were directed to those patients who were still working. Daily life activities and the amount of time spent on household chores and other leisure activities were inquired by question Q4. The questions Q1–Q4 were previously used in the Finnish Health and Functional Capacity Study.²⁵ Question Q6 was modified from the version used in a previous study assessing the barriers of physical activity among elderly adults.²⁶ The British Medical Research Council (MRC) dyspnea scale was used to evaluate patients' subjective dyspnea (Q8).²⁷ Response rates for individual questions varied between 96% and 100% (Table S1).

Terms defining patient's physical activity

Based on the recommendations of the American College of Sports Medicine and the American Heart Association,²⁸ patients were categorized as being "physically active" when they reported exercising at least 2–3 times a week and for at least 30 minutes each time, with an intensity causing shortness of breath and perspiration, throughout the year.

The exercise time per week was estimated based on Q1A and Q1B as follows: (1) daily = 210 minutes/week; (2) 2–3 times a week = 75 minutes/week; (3) once a week = 30 minutes/week; (4) 2–3 times a month = 19 minutes/week; (5) a couple of times a year or less = 0 minutes/week.

“Daily life activity” was estimated by summing up the amount of time during which patients performed different domestic/household chores and engaged in leisure activities (minutes/week; Q4). Question Q7 was designed to capture the most profound stages of physical inactivity. The “mobility score” was classified based on either no or minor restrictions in normal life (when the patient is mostly up all day and does light household chores in and outside of the home as needed), or based on the most severe restrictions (the patient rests all day and cannot leave his or her house without help).

Assessment of clinical characteristics

The participants' HRQoL was assessed using the self-completed, airway-specific AQ20^{29–32} and generic 15D³³ instruments. Each of the hospitals, health care centers, and other outpatient clinics that treated the patients was contacted to gather a complete medical history for each participant. The medical history encompassed the period at least 5 years prior to recruitment. The patients' social security numbers were used to combine the data from different sources and to link the data to each patient. From the medical records, we identified the results of the latest flow-volume spirometry including bronchodilation tests, and we also acquired information about each patient's weight, height, and smoking status. The latest spirometry was taken on average 1.7 ± 1.9 (SD) years before recruitment. The diffusing capacity test was only available for a subgroup of patients ($n = 294$).

The reference values for forced expiratory volume in 1 second (FEV₁) and volume- and blood hemoglobin level-corrected diffusing capacity (DLCOcVA) were validated across large Finnish population samples.³⁴ All of the diagnoses stated in the medical records were carefully evaluated, and particular attention was paid to the time of disease onset and certainty of the diagnosis. The category “coronary disease” included patients who had a myocardial infarct, acute coronary syndrome, or angina pectoris diagnosed by an internist. “Cardiovascular diseases” consisted of patients having one of the following diseases: coronary artery disease, cerebrovascular disease, or peripheral artery occlusive disease. Chronic alcoholism, alcohol use disorder, and treatment of an alcohol use-related disorder were all categorized as “alcohol abuse.” A wide range of psychotic disorders – including long-lasting clinical depression and anxiety disorders that required regular medication – were categorized as “psychiatric condition.” “Diabetes” included both type 1 and type 2 diabetes patients being treated with medication.

Statistical analysis

All statistical analyses were performed with the SPSS statistical software packages (version 17.0; IBM Corporation, Armonk, NY). Comparisons between the mean differences of the demographic and clinical characteristics of the patients in the subgroups were conducted using either the Chi-squared test or the Mann–Whitney test. Correlations between ordinal variables were compared using the Spearman's correlation coefficient (r). The logistic regression analysis was used to determine the independent risk factors associated with physical inactivity. The potential interactions between FEV₁ groups and exercise time, exercise activity, daily activity, and mobility were tested with two-way analysis of variance.

Results

Study subjects

The study cohort represented patients with smoking-related chronic bronchitis or COPD across all stages of the disease. The cohort was followed by way of their medical records since the year 2000. During March and April 2010, all participants received a postal questionnaire inquiring about their present exercise routines, sports that they practice, exercise restrictions, other daily activities, their mobility score, and their subjective level of dyspnea. During that time, the mean age in the cohort was 63 years and 40% of the patients were women. A total of 12% of the patients were employed and 52 (7.4%) of them indicated they had a physically strenuous job. The clinical characteristics collected from the medical records are shown in Table 1, and the translation of the questionnaire and the patients' responses are shown in Table S1.

Physical activity among COPD patients

When patients were divided into active and inactive categories based on their exercise routines, common demographic and clinical determinants such as age, sex, comorbidities, or health behavior (continuation of smoking and body mass index [BMI]) showed very little differences between the groups. FEV₁, forced vital capacity (FVC), and diffusion capacity were significantly better in physically active patients (Table 1). Exercise activity decreased in parallel with the progression of the disease ($P < 0.001$) (Figure 1). The proportion of patients with FEV₁ >80% of the expected value who exercised > 2 times a week throughout the year was 60% ($n = 60$); with FEV₁ 65%–80% of expected was 51% ($n = 96$); with FEV₁ 40%–64% of expected was 50% ($n = 143$); and with FEV₁ <40% of expected was 33% ($n = 35$) ($P = 0.001$).

Exercise activity was lower during the winter than during the rest of the year across all levels of severity of

Table 1 Comparison of the clinical characteristics between physically active (exercise > 2–3 times a week) and inactive COPD patients

Clinical characteristics	All patients	Physically active	Physically inactive
Sex			
Male	419 (60%)	210 (61%)	209 (59%)
Female	280 (40%)	133 (39%)	147 (41%)
Age mean (SD)	63.4 (7.0)	63.3 (7.0)	63.3 (6.9)
BMI mean (SD)	26.6 (5.2)	26.5 (4.8)	26.7 (5.6)
Change in weight within the last year (q16)			
No change	364 (53%)	193 (58%)	171 (48%)*
Increase > 2 kg	190 (28%)	81 (24%)	109 (31%)
Decrease > 2 kg	134 (20%)	61 (18%)	73 (21%)
Smoking (Q15)			
Current regular	210 (30%)	90 (27%)	120 (34%)*
Current irregular	59 (9%)	25 (7%)	34 (10%)
Ex-smoker	422 (61%)	222 (66%)	200 (57%)
Spirometry mean (SD)			
FEV ₁ % of expected	60.1 (18.5)	63.1 (18.0)	57.6 (18.7)**
FVC % of expected	75.2 (17.7)	77.8 (17.5)	72.9 (17.7)**
FEV ₁ /FVC %	64.5 (13.7)	65.6 (12.3)	63.7 (14.5)
Diffusion capacity[§] mean (SD)			
DLCOcVA % of expected	78.5 (22.3)	81.7 (21.4)	74.7 (22.6)**
Coexisting diseases			
Hypertension	295 (42%)	141 (41%)	154 (43%)
Psychiatric conditions***	147 (21%)	64 (19%)	83 (23%)
Coronary disease	132 (19%)	58 (17%)	74 (21%)
Alcohol abuse	102 (15%)	44 (13%)	58 (17%)
Diabetes	99 (14%)	43 (13%)	56 (16%)
Cerebrovascular disease	49 (7%)	23 (7%)	26 (7%)
Peripheral vascular disease	38 (6%)	24 (7%)	14 (4%)

Notes: * $P < 0.05$ for the Chi-square 2×3 contingency table; ** $P < 0.01$ when active and inactive groups were compared; ***medication in use; [§]data available for 294 patients.

Abbreviations: COPD, chronic obstructive pulmonary disease; BMI, body mass index; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; DLCOcVA, diffusing capacity corrected for alveolar volume.

the disease (Figure 1). Eighty-seven patients (20%) who exercised actively in the summer became inactive during the winter. Year-round exercise activity correlated significantly with the level of bronchial obstruction ($r = -0.14, P < 0.01$), diffusing capacity ($r = -0.20, P < 0.01$), mobility score (Q7) ($r = -0.31, P < 0.01$), daily life activity (Q4) ($r = -0.14, P < 0.01$), generic ($r = -0.23, P < 0.01$) and airway-specific HRQoL ($r = 0.19, P < 0.01$) (Table S2). Overall, the observed correlations were statistically significant, but many of these relationships were rather weak.

Interest in pulmonary rehabilitation

A total of 233 patients had previously been given guidance for training by health care professionals, and 15% ($n = 96$) had taken part in a 2-week inpatient ($n = 71$) or outpatient ($n = 25$) rehabilitation program (Table 2). A total of 14%

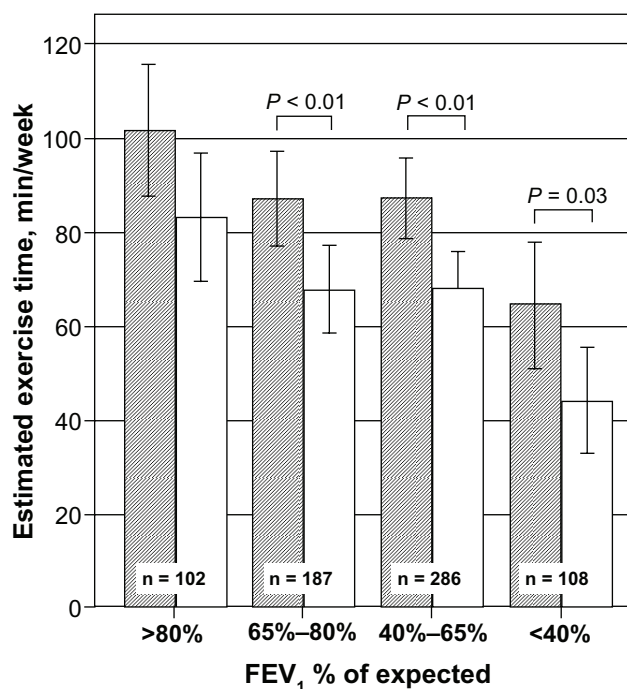


Figure 1 Seasonal changes in estimated exercise time (minutes/week) of patients with different FEV₁ % values.

Notes: Dark bars represent spring, summer, and autumn; light bars represent winter. Significant P-values of the difference between winter and other seasons within the FEV₁ % groups are given above the bars.

Abbreviation: FEV₁, forced expiratory volume in 1 second.

($n = 94$) of all patients had received exercise guidance from physicians; 58 of these patients (18%) were active and 36 (11%) were inactive. A history of competing in sports as a youth was not associated with the maintenance of exercise activity among the COPD patients. Sixty-two percent of the inactive patients compared with 54% of the active patients showed an interest in pulmonary rehabilitation ($P < 0.01$). Those who were interested were slightly younger (62.9 versus 64.1 years) than those who were not, but no difference was found based on disease severity, sex, or coexisting disease profiles. Whilst 71% of patients reported that COPD significantly restricts their exercising (Q9), the mobility score (Q7) was significantly pronounced within each FEV₁ class among inactive patients when compared to active patients (Figure 2). In daily life activities (Q4) the same trend was observed, even though the difference between active and inactive patients was significant only at the later stages of the disease, particularly when FEV₁ $\leq 64\%$ of expected was noted.

Dyspnea

Subjective dyspnea, assessed by the MRC dyspnea scale, showed constantly stronger correlations with patients' exercise activity ($r = 0.27, P < 0.01$), daily life activity

Table 2 Comparison of the patient-reported outcomes between physically active and inactive (exercise ≥ 2 –3 times a week) COPD patients

Patient-reported outcomes	All patients	Physically active	Physically inactive
Employed at the time of the survey (Q3)			
Yes	88 (12%)	38 (11%)	50 (14%)
No	598 (88%)	299 (89%)	299 (86%)
Competed in sports in youth (Q10)			
Yes	236 (35%)	118 (35%)	118 (34%)
No	446 (65%)	216 (65%)	230 (66%)
More than one way of exercising (Q5)	321 (47%)	204 (62%)	117 (34%)*
Everyday activities (Q4)	312 (284%)	347 (288%)	284 (276%)*
minutes/week mean (SD)			
Guidance for exercising because of COPD (Q11)			
Yes	233 (36%)	113 (36%)	120 (36%)
Yes by physician	94 (14%)	58 (18%)	36 (11%)*
Yes by nurse	56 (9%)	31 (10%)	25 (7%)
Yes by physiotherapist	135 (21%)	59 (19%)	76 (23%)
Rehabilitation due to pulmonary disease (Q12)			
Yes	96 (15%)	46 (14%)	50 (15%)
No	560 (85%)	275 (86%)	285 (85%)
Interest in rehabilitation (Q14)			
Yes	374 (58%)	168 (54%)	206 (62%)*
No	273 (42%)	146 (46%)	127 (38%)
Health-related quality of life			
Respiratory specific mean (SD)	8.1 (4.9)	7.2 (4.8)	9.0 (4.9)*
Generic mean (SD)	0.80 (0.10)	0.83 (0.09)	0.78 (0.11)*
Enough information about the role of physical activity in the prognosis of COPD (Q13)			
Yes	303 (46%)	151 (47%)	152 (45%)
No	357 (54%)	168 (53%)	189 (55%)
MRC dyspnea scale (Q8)			
0	64 (10%)	42 (13%)	22 (7%)*
1	253 (39%)	144 (46%)	109 (33%)
2	196 (31%)	102 (33%)	94 (29%)
3	93 (15%)	20 (6%)	77 (22%)
4	35 (6%)	5 (2%)	31 (9%)

Notes: * $P < 0.05$; ** $P < 0.01$ when active and inactive groups were compared; *** $P < 0.01$ for the Chi-square 2×5 contingency table.

Abbreviations: COPD, chronic obstructive pulmonary disease; MRC, British Medical Research Council.

($r = -0.37$, $P < 0.01$), mobility ($r = -0.46$, $P < 0.01$), airway-related ($r = 0.33$, $P = 0.01$), and generic HRQoL ($r = -0.40$, $P < 0.01$) levels than the FEV₁ or the diffusing capacity corrected for alveolar volume (Table S2). When FEV₁ was less than 65% of expected, the subjective perception of dyspnea was significantly stronger among inactive than active patients (Figure 3). Using two-way analysis of variance, we found a significant interaction ($P = 0.016$) between the FEV₁ and activity groups, suggesting that the sensation of dyspnea becomes disproportionately stronger as lung function decreases among the inactive patients when compared to the decrease in lung function among the active patients. The explanatory variables in Figures 1 and 2 were also tested, but no significant interactions between the variables and physical activity were found.

Barriers to exercising

The most frequently reported reasons preventing patients from exercising (Q6) were sensation of dyspnea (66%), pain (36%), other illnesses (42%), discomfort of strenuous exercise (20%), and poor weather (17%) (Table S1). The most common exercise-limiting diseases reported were musculoskeletal disorders ($n = 92$) and ischemic heart conditions ($n = 41$).

Physically active patients

When the active patients were studied in greater detail, their common factor seemed to be the greater variety of sport activities in which they engaged. When walking was excluded, the active patients ($n = 343$) practiced a specific sport more frequently than inactive patients (215 patients,

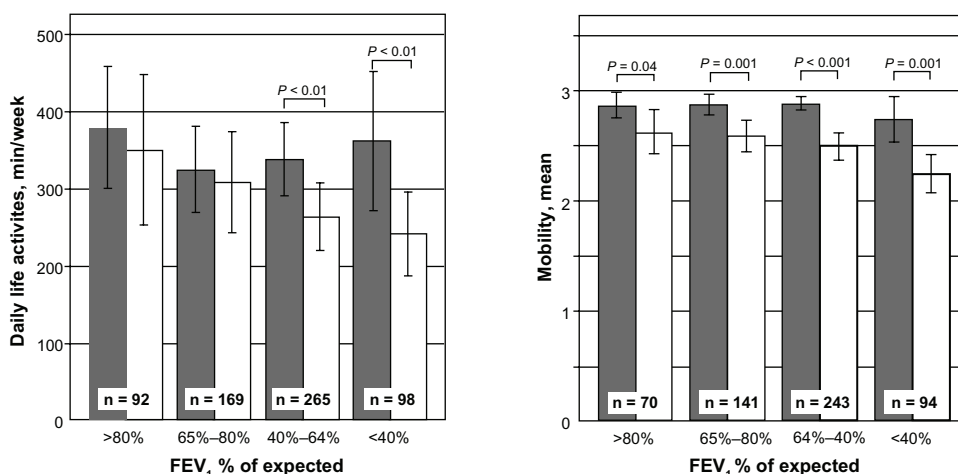


Figure 2 Daily life activities (minutes/week) and mobility score in different FEV₁ % classes. **Notes:** Dark bars represent active patients; light bars represent inactive patients; Mobility score 1 = rests inside most of the day, and cannot get out without help; 2 = stays up inside most of the day; 3 = moves in and out, doing light household chores when needed. **Abbreviation:** FEV₁, forced expiratory volume in 1 second.

or 63%, versus 119 patients, or 33%; $P < 0.001$). The top 12 sports that COPD patients favored differed greatly in terms of their metabolic equivalents, which are used to compare the intensity between different types of sport activities (Table 3).³⁵ Metabolic equivalent values ranged from 2.0 (slow walking) to 6.0 (swimming and skiing). In addition, COPD patients adopted a wide range of sport activities, including skiing, golf, yoga, asahi (Chinese-style gymnastics), badminton,

bowling, rowing, downhill skiing, sailing, and hiking. Even though high-intensity activities were practiced less often among patients with severe bronchial obstruction, some patients could still continue swimming, skiing, and participating in ballgames (Table 3). A total of 35 patients (32%) with FEV₁ < 40% of predicted levels continued to exercise actively.

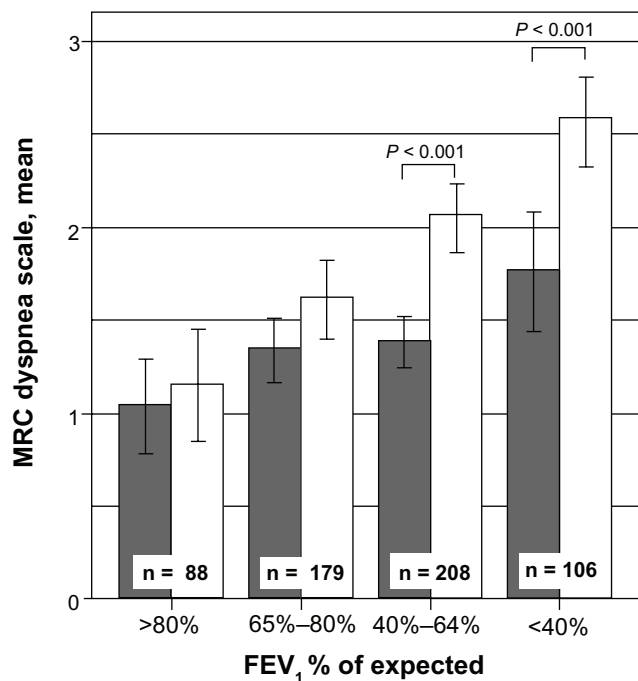


Figure 3 MRC dyspnea scale in different FEV₁ % classes among active and inactive patients as represented in the dark and light bars, respectively. **Abbreviations:** MRC, British Medical Research Council; FEV₁, forced expiratory volume in 1 second.

Clinical variables explaining variability in physical activity levels

In the multivariate model, we found that subjective dyspnea remained by far the most significant marker (OR 7–12, CI 95% 3–38, $P > 0.001$ at dyspnea levels 3–4) for exercise inactivity when the model was adjusted for sex, age, smoking status, BMI, and common comorbidities such as cardiovascular diseases, diabetes, psychiatric conditions, and alcohol diseases. FEV₁ explained exercise inactivity only at the late state of the disease (OR 3.5, CI 95% 1.8–6.9, when FEV₁ < 40% of expected was observed).

Discussion Main findings

Based on the present study, when COPD patients’ exercise activity was assessed by a self-reported questionnaire, 51% of the study subjects did not achieve the recommended minimum physical activity levels required to promote and maintain their health, as provided by the American College of Sports Medicine and the American Heart Association.²⁸ Most interestingly, we found that patients’ perceptions of dyspnea correlated more strongly with their exercise activity,

Table 3 Most popular sports practiced by the COPD patients according to airway obstruction

Sports	MET ^a	FEV ₁ > 80%	FEV ₁ 65%–80%	FEV ₁ 40%–64%	FEV ₁ < 40%	Total
Walking	3.8	51	73	81	11	216
Cycling	4.0	11	22	33	2	68
Swimming	6.0	13	17	16	2	48
Gym	4.5	10	17	14	6	47
Water-running	6.0	4	15	14	1	34
Exercising in a group	4.5	6	10	9	5	30
Water aerobics	5.0	4	13	10	2	29
Home gymnastics	4.0	7	4	6	4	21
Skiing	7.0	4	10	6	–	20
Walking slowly	2.0	2	5	8	4	19
Dancing	4.0	3	7	8	–	18
Ballgames	4.5	2	7	3	1	13

Note: ^aMetabolic equivalent providing a rough estimate for the intensity of physical activities.³¹

Abbreviations: COPD, chronic obstructive pulmonary disease; MET, metabolic equivalents; FEV₁, forced expiratory volume in 1 second.

daily life activity, mobility score, and HRQoL than with their level of bronchial obstruction. The subjective perception of dyspnea, captured by the MRC test, was significantly higher among inactive than active patients when FEV₁ was less than 65% of expected levels. In the multivariate model, dyspnea remained the most significant explanatory factor for exercise inactivity. The findings are further supported by study designs in which dyspnea was better correlated with patients' performance during a 6-minute walking test than with a patient's FEV₁ levels.^{36,37}

Even though the proportion of inactive patients increased in parallel with disease progression, the participants showed great variation in activity as well as in sport choices. Sports that COPD patients favored were no different when compared to those favored by others in the population that were age- and sex-matched.³⁸ The great majority of these patients exercised without any assistance from health care professionals, and only a minority of these patients had taken part in a pulmonary rehabilitation course or had received guidance about exercising. Across the whole cohort, 24% of the patients were extremely inactive during the wintertime, exercising only once or twice in the whole season, while the most active participants (10%) exercised daily. Significant seasonal variations in exercise activity were found, and year-round exercise activity levels were better maintained among patients who exercised indoors (36% of the study subjects). Based on demographics, comorbidities, or health behavior, active and inactive patients were very similar.

Limitations and strengths of the study

The study population was large and represented all severity levels of the disease. The gathered clinical variables were valid and comprehensive, but relied completely on

retrospective health care data. The assessment of exercise activity was based on two questions, which were used in two previous Finnish Health Surveys in 2000 and 2011, allowing us to compare the results among COPD patients in subsequent studies with members of the Finnish population at large.²⁵ These surveys also employed the more established International Physical Activity Questionnaire with extremely poor response rates. Based on that experience, we decided to use these two basic questions (Q1A and Q1B), which guaranteed us excellent response rates (98% and 97%, respectively), but the answers to these questions contained limited information. In particular, the intensity level of physical training was very roughly approximated.

Since our study relies completely on retrospective lung function data, the spirometry results presented here were not performed at the same time as the questionnaire survey, and this may have weakened the correlations observed in our results. The latest spirometry results were taken, on average, 1.7 years prior to recruitment. However, we had collected an average of 5.5 spirometry tests per patient during the follow-up period,²⁴ and we performed simple sensibility testing using participants' baseline and bronchodilation spirometry results from different time points; we found that our basic findings did not change (data not shown). Thus, the time difference between the questionnaire survey and the physiological measures may not have played a major role in our results.

In addition to obstruction, restrictive impairment of FVC and thus the FEV₁/FVC ratio > 0.7 is rather common in COPD.^{39,40} To avoid exclusion of a significant number of patients with combined lung function impairments from the analysis, we chose to classify the level of airway obstruction solely based on the FEV₁ instead of the Global Initiative for

Chronic Obstructive Lung Disease (GOLD) measurements. Unfortunately, diffusion capacity was available only for 285 patients, but the preliminary results showed an even smaller correlation between the sensation of dyspnea and exercise activity.

Interpretation of findings in relation to previously published work

Compared to an epidemiological study conducted in Sweden ($n = 526$)⁵ in which 84% of COPD patients were inactive, the Finnish COPD patients reported a higher level of physical activity. The difference can be at least partially explained by the 10-year age difference between the study populations. The patients in the present study have been participating actively for many years, and thus, to some degree, might represent a selected patient population. However, compared to the population from the Copenhagen Heart Study ($n = 6568$), in which patients participated actively, the exercise activity levels noted in this study were more similar to the levels noted in our study.⁹ Approximately 19% of the Danish COPD patients showed low, 50% moderate, and 32% high physical activity levels.

Interesting details in the activity profile

Wintertime physical activity was evaluated separately from the rest of the year since COPD patients tend to become more symptomatic in cold and humid weather.⁴¹ The winter season before the study began was colder than average, as the temperature in southern Finland was below 0°C for 60 days. Our results confirmed that exercise activity decreased during the winter months when FEV₁ was under 80% of expected levels. This might partially explain why year-round activity was better maintained among patients who also practiced indoor sports. A total of 17% of patients reported poor weather as a barrier to exercising; on the other hand, dog-walking was a rather popular leisure activity among 10% of the COPD patients from our study (Table S1), suggesting that motivation helps COPD patients tolerate cold weather. A history of competing in sports as a youth was reported in 35% of patients; contrary to findings noted among healthy individuals, no protection against physical inactivity was observed compared to their noncompeting counterparts at the time of the survey.⁴² It seems that COPD is a strong trigger for physical inactivity even among previous athletes. It is not known whether these former athletes would be more successful at restoring their physical capability and maintaining their exercise activity after pulmonary rehabilitation interventions than

those who did not have a history of participating in sports as youth.

Implications for future research, policy, and practice

Dyspnea is the main symptom of COPD. This subjective experience of breathing discomfort is multidimensional, deriving from physiological, psychological, social, and environment factors, and is not directly comparable with physiological measurements.^{43,44} Limitations in exercise capacity among patients with COPD occur due to ventilatory limitation, dynamic hyperinflation, disturbances in respiratory muscles, ventilatory and vascular capacity imbalance, reduced oxygen uptake and hypoxemia, blood gases, and muscular metabolics.^{44,45} It is poorly understood why a significant proportion of patients who have very severe bronchial obstruction maintain remarkable levels of physical activity, while others start to lose their exercise capacity at early stages of disease.^{2,9}

Large variations in COPD patients' exercise capacity have also been described in studies in which patients' physical activity levels were measured with motion sensors.¹⁻³ Dyspnea was strongly associated with exercise activity among the participants, even when adjusted for FEV₁ and other clinically valid variables such as age, sex, comorbidities, smoking status, or BMI. This suggests that COPD either harms cardiovascular exercise capacity by mechanisms other than airway obstruction, or that dyspnea is secondary to physical inactivity and is a marker of overall impaired physical fitness. Pulmonary rehabilitation, combined with pre- and post-intervention physiological measurements for exercise capacity, will be of value in examining the causality between dyspnea and inactivity.

Conclusion

The present study suggests that patients' subjective sensations of dyspnea may be an indicator that patients' exercise routines should be assessed. On the other hand, the patients in the cohort currently studied reported dyspnea as the most common barrier to exercise. We should inform inactive patients that dyspnea is not a barrier for exercising and encourage them to exercise despite the sensation of dyspnea. Most of the current rehabilitation programs do not acknowledge patients' exercise history, nor do they aim to create more tailored programs, which would ultimately support the patient's own exercise preferences. These programs might achieve better long term results by introducing a variety of indoor and outdoor sports, which

may help the patient find the most attractive ways for him or her to train and enjoy exercise.

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Supplementary material

Table SI COPEX questionnaire and response rates among 719 COPD patients

COPEX questionnaire		Response rate n (%)	
Q1A	How often do you exercise at least half an hour at a time during the spring, summer, and autumn seasons (at least mildly perspiring and being out of breath)?		
	1. Daily	113	(16.1%)
	2. 4–6 times a week	117	(16.6%)
	3. 2–3 times a week	202	(28.7%)
	4. Once a week	85	(12.1%)
	5. 2–3 times a month	65	(9.2%)
	6. A few times or less	121	(17.2%)
		Total 703	
Q1B	How often do you exercise at least half an hour at a time during the winter season (at least mildly perspiring and getting out of breath)?		
	1. Daily	71	(10.1%)
	2. 4–6 times a week	78	(11.1%)
	3. 2–3 times a week	202	(28.8%)
	4. Once a week	109	(15.5%)
	5. 2–3 times a month	71	(10.1%)
	6. A few times or less	170	(24.3%)
		Total 701	
Q2	How many minutes do you walk or cycle daily on your way to work?		
	1. I do not work or I work at home	611	(87.8%)
	2. I go to work by motor vehicle	35	(5.0%)
	3. <15 minutes a day	12	(1.7%)
	4. 15–29 minutes a day	17	(2.4%)
	5. >30 minutes a day	21	(3.0%)
		Total 696	
Q3	How physically strenuous is your work?		
	1. I do not work	614	(87.3%)
	2. I mostly sit	37	(5.4%)
	3. I walk a lot, but I do not lift or carry heavy items	24	(3.4%)
	4. I walk a lot, lift and carry items, and climb stairs or uphill	23	(3.3%)
	5. My work is heavy physical labor	5	(0.7%)
		Total 703	
Q4	Domestic activities that you do every week (mean ± SD)	Time (min)	Mean*
	1. Vacuuming, cleaning _____ h _____ min/week	430 (60%)	85 (±66)
	2. Gardening, yard work _____ h _____ min/week	197 (27.5%)	206 (±192)
	3. Shopping _____ h _____ min/week	572 (80%)	157 (±116)
	4. Taking care of children _____ h _____ min/week	42 (5.9%)	362 (±386)
	5. Taking the dog out _____ h _____ min/week	72 (10%)	383 (±246)
	6. Something else _____ h _____ min/week	79 (11%)	313 (±300)
		Total 716	
Q5	Sports that you have practiced during the last year		
	Gym workout	62/9%	
	Gymnastics	21/3%	
	Dancing (anything)	18/3%	
	Walking	235/33%	
	Jogging	4/1%	
	Cycling (in or out)	68/9%	
	Swimming	48/7%	
	Water aerobics	29/4%	
	Water running	34/5%	
	Yoga	7/1%	
	Skiing	20/3%	
	None	194/27%	

(Continued)

Table S1 (Continued)

COPEX questionnaire		Response rate n (%)
Q6	My exercising is restricted because (of):	
	1. Shortness of breath	480 (67%)
	2. Other illnesses (three most common)	301 (42%)
	3. Pain	260 (36%)
	4. I have been warned not to stress myself physically	44 (6.1%)
	5. Strenuous exercise feels uncomfortable	146 (20%)
	6. I do not feel safe outdoors	46 (6.4%)
	7. Why should I exercise?	10 (1.4%)
	8. I don't know where to exercise	22 (3.1%)
	9. I don't know how to exercise	13 (1.8%)
	10. I don't have time to exercise	13 (1.8%)
	11. I lack the company	51 (7.1%)
	12. Bad weather conditions	121 (17%)
	13. Exercising is too expensive	37 (5.2%)
	14. I have no possibilities to exercise in the neighborhood	17 (2.4%)
	15. Fear of injury	48 (6.7%)
	16. Another obstacle: what?	88 (12%)
Q7	If pulmonary disease prevents your exercising, which of the next choices describes your situation best?	
	1. I am mostly up all day doing light household duties in- and outside when needed	36 (6%)
	2. I stay most of the day inside resting, and go out only when it is necessary	130 (23%)
	3. I stay most of the day inside resting and need help when I leave the house	397 (71%)
	Total	563
Q8	Which of the following describes your situation best?	
	0. Not troubled with breathlessness except with strenuous exercise	69 (10.3%)
	1. Troubled by shortness of breath when hurrying on the level or walking up a slight hill	263 (39%)
	2. Walk slower than people of the same age on the level because of breathlessness or have to stop for breath when walking at own pace on the level	202 (30%)
	3. Stop for breath after walking about 100 yards or after a few minutes on the level	96 (14.3%)
	4. Too breathless to leave the house or breathless when dressing or undressing	41 (6.1%)
	Total	671
Q9	Has your pulmonary disease affected your exercise habits?	
	1. I have given up exercising	71 (11%)
	2. I have significantly diminished exercising	219 (34%)
	3. I have started exercising	62 (9.6%)
	4. I avoid all strenuous physical activity and shortness of breath	95 (15%)
	5. I have not changed my exercise habits	198 (31%)
	Total	645
Q10	Did you compete in sports during your childhood or adolescence?	
	Yes	244 (35%)
	No	454 (65%)
	Total	698
Q11	Have you received any guidance on how to exercise due to your pulmonary disease?	
	1. No, I have not	445 (65%)
	2. Yes, from a physician	97 (14%)
	3. Yes, from a physiotherapist	144 (21%)
	4. Yes, from a nurse	57 (8.3%)
	5. Yes, from somebody else: who?	39 (5.6%)
	Total	690
Q12	Have you previously participated in pulmonary rehabilitation?	
	1. Yes, as an inpatient for a rehabilitation course for several days in row	71 (10%)
	2. Yes, guidance by a physiotherapist to exercise by myself or as an outpatient under supervision in a group	25 (3.8%)
	3. No, I have not	590 (85%)
	Total	691
Q13	Have you got enough information about the role of physical activity in prognosis of your pulmonary disease?	
	1. Yes	316 (46%)
	2. No	377 (54%)
	Total	693

(Continued)

Table S1 (Continued)

COPEX questionnaire		Response rate n (%)
Q14	Would you be interested in participating in pulmonary rehabilitation supporting, in particular, physical activity and coordinated by a lung physician and physiotherapist?	158 (23.2%)
	1. Yes, 1–3 times a week in a small group for 2–3 months	229 (34%)
	2. Yes, 1–2 weeks as an inpatient in a rehabilitation center	192 (28%)
	3. I exercise as much as possible. I do not believe that I need pulmonary rehabilitation	102 (15%)
	4. I am not interested in pulmonary rehabilitation	Total 681
Q15	Have you been smoking during the last 6 months?	212 (29.9%)
	1. Daily	61 (8.6%)
	2. Every now and then	436 (61.5%)
	3. Not at all	Total 709
Q16	During the last 6 months, has your weight	374 (53%)
	1. Stayed the same?	195 (28%)
	2. Increased 2 kilograms or more?	137 (19%)
	3. Decreased 2 kilograms or more?	

Abbreviations: COPEX, COPd Exercise Study; COPD, chronic obstructive pulmonary disease.

Table S2 Correlation table between clinical variables and specific items in the questionnaire used in the COPEX study

		Year-round activity	Domestic activities (Q4)	FEV ₁ from expected	DLCOcVA from expected	Subjective dyspnea MRC scale	Mobility score (Q7)	AQ20 score	15D score
Year-round activity	Correlation coefficient	1.000	-0.137**	-0.174**	-0.195**	0.266**	-0.314**	0.188**	-0.226**
	N	679	679	662	274	642	538	679	654
Domestic activities (Q4)	Correlation coefficient		1.000	0.089*	-0.033	-0.241**	0.368**	-0.088*	0.165**
	N		697	679	283	656	550	697	671
FEV ₁ from expected	Correlation coefficient			1.000	0.278**	-0.358**	0.172**	-0.222**	0.142**
	N			679	283	638	536	679	655
DLCOcVA from expected	Correlation coefficient				1.000	-0.254**	0.088	-0.167**	0.104
	N				283	263	224	283	279
Subjective dyspnea MRC scale	Correlation coefficient					1.000	-0.457**	0.483**	-0.452**
	N					656	527	656	632
Mobility score (Q7)	Correlation coefficient						1.000	-0.326**	0.403**
	N						550	550	528
AQ20 score	Correlation coefficient							1.000	-0.705**
	N							697	671
15D score	Correlation coefficient								1.000
	N								671

Notes: *P < 0.05; **P < 0.01.

Abbreviations: COPEX, COPd Exercise Study; DLCOcVA, diffusing capacity corrected for alveolar volume; MRC, British Medical Research Council; FEV₁, forced expiratory volume in 1 second.

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