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A community-based exercise programme in COPD self-management: Two years follow-up of the COPE-II study

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Summary
Introduction: It is still unknown how best to maintain effects of exercise programmes in COPD in the long-term. We present the long-term effects of a community-based exercise programme incorporated in a self-management programme, compared to a self-management programme only in patients with COPD.
Methods: All included patients participated in four self-management sessions. Additionally, patients in the intervention group participated in an 11-month community-based exercise programme led by physiotherapists. Patients trained three times/week for six months and two times/week during the subsequent five months. To encourage a behavioural change towards exercise, one of these weekly training sessions was home-based (unsupervised). No formal exercise training was offered to intervention patients in the second year.
Results: The intervention was assigned to 80 patients, and the control condition to 79 patients. 82.5% and 78.5% of the intervention and control group, respectively, completed 24 months follow-up. Modified intention-to-treat analyses were performed. Although statistically significant after 12 months (35.1 m (95%CI: 8.4–61.8)), the between-group difference on maximal exercise capacity was not statistically significant after 24 months (12.2 m (95%CI: −16.6 to

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41.0). Nevertheless, the between-group difference in daily physical activity was maintained after 24 months (1193 steps/day (95%CI: 203—2182)). A beneficial effect was also found on CRQ dyspnoea score but not on other CRQ domains, CCQ and HADS.
Conclusions: Our intervention was effective in achieving a behavioural change reflected by a sustained increase in daily physical activity, not accompanied by a sustained increase in maximal exercise capacity after two years of follow-up (ISRCTN81447311).

Introduction

Chronic obstructive pulmonary disease (COPD) is not only characterized by symptoms of dyspnoea, chronic cough, and sputum production, but also and importantly by decreased exercise capacity [1] and a reduced physical activity level [2—4]. A large number of randomised controlled trials have investigated the effects of exercise training programmes, whether part of a formal pulmonary rehabilitation programme or not, on exercise capacity in patients with COPD. A meta-analysis of Lacasse et al. [5] included 31 randomised trials, and found that rehabilitation programmes including exercise therapy are effective in improving exercise capacity and quality of life. However, in this review only short-term effects (i.e. effects directly after the end of the intervention) were assessed. The results on the longer term are less unanimous [6—9].

It is increasingly recognised that the long-term maintenance of beneficial effects of exercise programmes in patients with COPD is problematic [1,10,11]. The leading hypothesis in this discussion is that one should not solely aim at the improvement of exercise capacity but also at a behavioural change towards exercise and physical activity [1,10,11]. Self-management training can play an important role in this context and is increasingly offered to patients with COPD, regularly combined with exercise programmes [1]. The goal of self-management is to teach patients the skills they need to carry out disease specific medical regimens, and to guide behaviour change to help patients control their own condition and improve their wellbeing [12,13]. Although self-management training is effective in improving quality of life and reducing respiratory-related hospitalisations, it remains unclear which components contribute most to its effectiveness [14].

The COPE-II study is a randomised controlled trial that evaluated the effects of a community-based physiotherapeutic exercise programme (COPE-active) within a self-management programme [15]. One of the main goals of the COPE-active programme was to achieve a behaviour change towards exercise in daily life. A relatively long training period of 11 months was chosen to facilitate the change from training under supervision of a physiotherapist to unsupervised exercise at home. To support this further, one training session was home-based and unsupervised during the entire training period. After one year of follow-up, patients who participated in the COPE-active programme showed an improved maximal exercise capacity and a positive change in daily physical activity in comparison with the control group [15]. On the short term, directly after the end of the structured exercise programme, the goal of behavioural change was therefore achieved. The current paper reports the long-term effects of the COPE-active programme on exercise capacity and daily physical activity in patients with COPD, i.e. after two years of follow-up.

Methods

Study design

The detailed study design was published earlier [15,16]. In the COPE-II study a 2 × 2 factorial design was used. This means that two independent interventions, a community-based exercise programme and self-treatment of exacerbations, were evaluated in one design. In this report, the effectiveness at two years follow-up of a community-based exercise programme incorporated in a self-management programme was compared to the effectiveness of a self-management programme only. Both treatment regimens were allocated using a minimisation programme [17], and patients receiving guidelines for self-treatment were equally distributed over the COPE-active programme and the control group. Patients were assessed at baseline, after 7, 12, 18 and 24 months.

Patients

From November 2004 through July 2006, participants were recruited from the outpatient department of pulmonary medicine [15]. Patients eligible for inclusion had a clinical diagnosis of COPD according to the GOLD criteria [18]; a post-bronchodilator FEV_1 between 25 and 80% of predicted; additionally, they had to have had at least three exacerbations or one hospitalisation for respiratory problems in the two years preceding study entry. Patients were excluded when they had a serious other disease with a low survival rate; another disease that influenced bronchial symptoms and/or lung function; a need for regular oxygen therapy; a disorder or progressive disease that seriously influenced walking ability. The study protocol was approved by the medical—ethical review committee of Medisch Spectrum Twente hospital and written informed consent was obtained from all participants [15]. The COPE-II study was registered in the ISRCTN register (ISRCTN81447311).

Self-management sessions and COPE-active programme

All patients participated in four weekly 2-h small-group (approximately 5 patients) self-management sessions led by a respiratory nurse and a physiotherapist. The goal of the course was to change the patients' disease behaviour by increasing their knowledge, confronting them with consequences of specific behaviour, and supplying them with tools to deal with different components of their disease. The respiratory nurse contacted all patients by telephone 4, 13 and 26 weeks after the last course to recall the items addressed during the self-management courses. Patients were supplied with a booklet with the content of the courses [15].

Only patients in the intervention group participated in a community-based physiotherapeutic exercise programme (COPE-active), of which details were published earlier [15]. The COPE-active programme was divided in two parts: a 'compulsory' 6-month, and a subsequent optional but recommended 5-month training period. In the first period, patients trained three times per week, and in the second period patients trained two times per week. In both periods, one of these weekly training sessions was performed at home to encourage the patients to exercise in their own environment. The training sessions consisted of cycling, walking, climbing stairs, and lifting weights. Besides improvement of physical condition, the main goal of COPE-active was a behaviour change towards exercise. The intensity of the programme was tailored to the individual patient's performance level by providing the physiotherapist with the baseline results of the cardio-pulmonary exercise test, and the incremental shuttle walk test. After the 11-month supervised training period, patients in the COPE-active group were advised to continue the unsupervised training at home, but not to follow any formal physiotherapeutic exercise training programme. Instead, the patients were encouraged to participate in other forms of community-based exercise.

Outcome measures

The primary outcome was maximal exercise capacity measured with the incremental shuttle walk test (ISWT) according to the protocol of Singh et al. [19] using a 10-m course. A practice walk was performed before the baseline measurement. According to current standard, an individual change of at least 47.5 m is considered clinically important [20]. Endurance capacity was measured with the endurance shuttle walk test (ESWT) using a 10-m course and a walking speed of 85% of the maximal ISWT walking speed [21]. Daily physical activity was assessed by the number of steps measured with a pedometer (Yamax Digi-Walker SW-200; Tokyo, Japan) during a 7-day period. HRQoL was measured by the self-administered standardised Chronic Respiratory Disease Questionnaire (CRQ-SAS) [22]. An individual change of at least 0.5/domain (dyspnoea, fatigue, emotional functioning, mastery) is considered clinically important [23]. Health status was evaluated by the self-administrated Clinical COPD Questionnaire (CCQ) [24]. A change of 0.4 is considered to represent a minimal important difference at the individual level [25]. Anxiety and depression were measured with the Hospital Anxiety and Depression Scale (HADS) [26]. This instrument produces separate scores for anxiety and depression ranging from 0 to 21.

Statistical analysis

Between-group differences in continuous variables over time were assessed by analysis of repeated measurements with fixed effects (SPSS procedure for mixed models, version 20). Baseline values were subtracted from follow-up values to correct for baseline differences. A modified intention-to-treat approach was used for all primary analyses, meaning that all patients who completed at least the baseline measurement were included in the analyses. Secondary, a per protocol analysis was performed on the primary outcome, maximal exercise capacity, in order to assess the effects of the programme in patients who adhered to the exercise programme. Adherence was defined as participation in at least 70% of the sessions.

The one year effects as presented in the text of the results section were obtained from the one year analyses as published earlier [15]. These values deviate from the one year values in the current two year analysis as presented in Tables 2 and 4. Due to the additional data collected in the second year of follow-up, estimations of missing values are slightly different in the first year compared to the second year, resulting in slightly different outcomes.

Results

Patients and follow-up

The intervention (community-based exercise programme) was assigned to 80 of the 159 included patients, while the control condition was assigned to 79 of them (Fig. 1). After one year of follow-up, 74 (92.5%) patients in the intervention group 68 (86.1%) patients in the control group still participated. In the second year of follow-up, an additional eight patients in the intervention group and six patients in the control group were lost-to-follow up, resulting in 66 (82.5%) and 62 (78.5%) patients, respectively, completing

Table 1 Baseline characteristics.

	COPE-active	Control
Number of patients	77	76
Age (years)	63.1 ± 8.1	64.1 ± 7.7
Gender (%male)	58.4%	57.9%
Body mass index (kg/m^2)	26.1 ± 5.0	26.8 ± 4.4
Smokers	35%	34%
Medical Research Council dyspnoea scale	2.25 ± 1.05	2.50 ± 1.15
FEV_1 (L)	1.43 ± 0.54	1.40 ± 0.53
FEV_1 (% of predicted)	49.6 ± 14.2	50.5 ± 17.0
VC (L)	3.78 ± 1.05	3.47 ± 0.84

Data are presented as mean ± standard deviation (sd) unless otherwise stated.

Table 2 Baseline scores and mean changes from baseline at 12, 18 and 24 months of exercise capacity and physical activity in the COPE-active and control group.

		Difference from baseline				Between-group difference (I vs. C)	
		Baseline	12 months	18 months	24 months	Δ 24 months	Overall[a]
		Mean (95% CI)	Mean (95% CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)	Mean (95%CI)
ISWT-I	Nr of patients	77	69	66	62		
	Distance (meters)	387.7 (350.3; 425.0)	10.8 (−8.7; 30.4)	−14.7 (−34.5; 5.0)	−30.4 (−50.4; −10.3)	12.2 (−16.6; 41.0)	23.5 (−1.93; 49.0)
ISWT-C	Nr of patients	74	66	60	57		
	Distance (meters)	341.4 (306.0; 376.7)	−24.3 (−44.5; −4.1)	−37.9 (−58.5; −17.4)	−42.6 (−63.5; −21.7)		
ESWT-I	Nr of patients	77	68	66	62		
	Distance (meters)	687.9 (553.3; 804.4)	48.8 (−75.0; 172.6)	−73.5 (−212.0; 65.0)	−100.6 (238.8; 37.7)	52.1 (−145.6; 249.8)	99.2 (−67.0; 265.5)
ESWT-C	Nr of patients	74	66	60	57		
	Distance (meters)	629.5 (501.1; 757.9)	−92.8 (−220.5; 34.9)	−158.4 (−302.6; −14.3)	−152.7 (−296.5; −8.9)		
Pedometer-I	Nr of patients	62	55	50	47		
	Steps (n per day)	4472 (3783; 5162)	811 (145; 1478)	584 (−100; 1267)	648 (−56; 1352)	1193 (203; 2182)	924 (172; 1676)
Pedometer-C	Nr of patients	65	55	47	47		
	Steps (n per day)	5224 (4366; 6082)	−367 (−1029; 295)	−203 (−899; 493)	−545 (−1246; 157)		

I: COPE-active group; C: control group; ISWT: incremental shuttle walk test; ESWT: endurance shuttle walk test.
[a] Intention to treat analysis. Results were obtained with repeated measurements analysis.

the two years follow-up (Fig. 1). Reasons for drop out were comparable between the groups (Fig. 1). Six patients dropped out before the baseline measurements, so baseline characteristics of 153 patients are presented in Table 1.

Exercise capacity

Maximal exercise capacity was measured with the ISWT. After one year of follow-up, directly after the end of the supervised exercise programme, there was a statistically significant between-group difference in mean change from baseline in walking distance of 35.1 m (95%CI: 8.4–61.8). After two years of follow-up the between-group difference in mean change from baseline in walking distance was reduced to 12.2 m (95%CI: −16.6–41.0) (Fig. 2A), with better performance in the COPE-active group, but no longer statistically significant (Table 2).

Endurance capacity was measured with the ESWT. After one year of follow up, the between-group difference in mean change from baseline in walking distance was 145.8 m (95%CI: −26.2 to 317.8) in favour of the intervention group, but not statistically significant. After two years this difference was reduced to 52.1 m (95%CI: −145.6 to 249.8) (Table 2).

Daily physical activity

Daily physical activity was measured with a pedometer. The change from baseline in mean number of steps per day was calculated over a 7-day period. After one year of follow-up, there was a statistically significant between-group difference in mean change from baseline in number of steps/day of 1190.4 (95%CI: 255.6–2125.2) in favour of the COPE-active group. After two years of follow-up this between-group difference was maintained, and still statistically significant, with 1193 steps/day (95%CI: 203–2183) (Fig. 3 and Table 2).

Pedometer data at 24 months were missing in 26 (34%) patients in both groups (28 due to drop-out, and 24 due to other reasons). We assessed whether patients who had not completed the pedometer measurement at 24 months of follow-up were different with regard to baseline characteristics from patients who had completed the measurement. Patients with a missing pedometer measurement at 24 months follow-up were in a worse functional state at baseline than patients who had a pedometer measurement at that point of time (Table 3). The degree in which this influenced total group means was comparable in both groups and ranged from 0% to 8%.

Health status

As reported after one year, no between-group differences in mean scores were found in any domain of the CCQ or the domains of fatigue, emotional function and mastery of the CRQ after two years. The CRQ domain of dyspnoea showed a between-group difference in mean score of 0.30 points (95%CI: −0.14 to 0.74) after two years of follow-up, which was comparable to the

Table 3 Baseline characteristics of patients with and without a pedometer measurement at 24 months follow-up.

	COPE-active group		Control group	
	With	Without	With	Without
Nr of patients	51	25	50	25
Age (years)	63.2 ± 7.6	63.1 ± 9.3	63.9 ± 7.5	64.4 ± 8.5
Nr of patients	51	25	50	25
FEV_1 (L)	1.49 ± 0.53	1.29 ± 0.56	1.43 ± 0.51	1.35 ± 0.57
Nr of patients	51	26	50	26
FEV_1 (% of predicted)	50.1 ± 13.2	48.5 ± 16.3	50.6 ± 15.9	50.3 ± 19.4
Nr of patients	51	25	50	25
VC (L)	3.9 ± 1.1	3.5 ± 1.0	3.6 ± 0.8	3.2 ± 0.8
Nr of patients	51	26	48	26
ISWT	408.6 ± 166	346.5 ± 156.5	380.2 ± 142.2	269.62 ± 146.8
Nr of patients	51	26	48	26
ESWT	709.8 ± 565.6	618.2 ± 533.2	764.7 ± 612.8	379.8 ± 300.9
Nr of patients	47	15	47	18
Pedometer	4768 ± 2831	3547 ± 2141	5599 ± 3764	4244 ± 2329

Data are presented as mean ± standard deviation (sd). ISWT: incremental shuttle walk test; ESWT: endurance shuttle walk test.

difference after one year (0.32 points (95%CI: −0.03 to 0.67)). The overall difference over two years between the intervention and control group was statistically significant (0.35 (95%CI: 0.03—0.67)) but did not reach the minimal important difference of 0.5. Anxiety and depression were assessed with the HADS. There were no statistically significant differences in both these domains (Table 4).

Per protocol analysis ISWT

In our secondary per protocol analysis on the ISWT, we predefined patients who participated in at least 70% of the physiotherapy sessions as treated per protocol, i.e. as patients who sufficiently adhered to the programme. This was the case in 67.5% of the patients. These patients who adhered well, increased their mean walking distance with 24.9 m (95%CI: −2.0 to 51.8) after 12 months of follow-up as compared to 11.1 m (95%CI: −10.0 to 32.2) in the group also including the poor adherers. After two years of follow-up, the loss in exercise capacity in the group with solely adherers was smaller than in the total group (−18.4 (95%CI: −42.4 to 5.7) vs. −30.4 (95%CI: −50.4 to −10.3) meters compared to baseline). The overall between-group difference of 34.1 m (95%CI: 5.9—62.3) over 24 months was, in contrast to that in the intention-to-treat analysis, still statistically significant but did not reach the minimal clinically important difference of 35.1 m (Fig. 2B).

Discussion

The goal of this study was to compare the long-term effects of a community-based exercise programme incorporated in a self-management programme with the effects of a self-management programme only in patients with COPD. Maximal exercise capacity as measured with the ISWT was substantially better in the intervention group compared to the control group after one year of follow-up, but this initial increase was not maintained in the second year of follow-up. As a consequence, the overall benefit measured over two years was not statistically significantly different between the two groups. In contrast with this, the beneficial effect on daily physical activity was maintained after two years. After 24 months, the intervention still had a positive effect on the CRQ dyspnoea domain, but no statistically significant effects were seen on the other CRQ domains, the CCQ, the HADS, and the ESWT.

Only a few studies have used the ISWT to address long-term effects of exercise programmes, mainly classified as pulmonary rehabilitation, on exercise capacity in patients with COPD. Two of these studies, with intervention periods of six and eight weeks, found a decline in ISWT walking distance in the year following the initial intervention period in the intervention group, but also a more gradual decline in exercise capacity in the control group during the entire period of follow-up [8,9]. As a result, differences in walking distance between the intervention and the control group were still statistically significant after one year of follow-up [8]. Two other studies on long-term effects of exercise in patients with COPD measured exercise capacity with the six minute walking test (6MWT) [6,7]. Duration of the interventions in these studies was more comparable to that of our intervention, namely six and 12 months. Beneficial effects of these programmes on 6MWT distance were maintained after 18 and 24 months follow-up, respectively. The results of studies assessing long-term maintenance of exercise capacity after an exercise programme are therefore ambiguous.

The loss in exercise capacity in the second year of follow-up in our study is probably due to a combination of the discontinuation of regular exercise training and the progressive character of COPD. Patients in this study suffered from relatively severe disease with relatively frequent exacerbations, and it is known that each exacerbation negatively influences the functional state of the patient [27]. Patients were encouraged to participate in some sort of community-based exercise (e.g. general or respiratory specific exercise programmes not reimbursed as

Table 4 Baseline scores and mean differences from baseline at 12, 18 and 24 months of health status in the COPE-active and control group.

		Difference from baseline[a]				Between-group difference	
		Baseline	12 months	18 months	24 months	Δ 24 months	Δ Overall[a]
		Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95% CI)	Mean (95%CI)	Mean (95%CI)
CRQ-I	Nr of patients	77	71	68	65		
	Dyspnoea	4.40 (4.08; 4.73)	0.30 (0.06; 0.54)	0.24 (−0.04; 0.52)	0.08 (−0.24; 0.39)	0.30 (−0.14; 0.74)	0.35 (0.03; 0.67)
	Fatigue	4.55 (4.27; 4.83)	0.14 (−0.16; 0.43)	0.09 (−0.21; 0.39)	−0.07 (−0.38; 0.23)	−0.02 (−0.45; 0.42)	0.08 (−0.27; 0.43)
	Emotional function	5.14 (4.88; 5.41)	0.18 (−0.04; 0.4)	0.04 (−0.19; 0.26)	0.27 (0.05; 0.50)	0.23 (−0.10; 0.55)	0.12 (−0.12; 0.37)
	Mastery	5.35 (5.09; 5.61)	0.33 (0.08; 0.57)	0.14 (−0.11; 0.39)	0.13 (−0.12; 0.38)	0.25 (−0.11; 0.61)	0.16 (−0.13; 0.45)
CRQ-C	Nr of patients	76	68	63	60		
	Dyspnoea	4.52 (4.21; 4.84)	−0.01 (−0.26; 0.23)	−0.19 (−0.48; 0.1)	−0.22 (−0.54; 0.1)		
	Fatigue	4.13 (3.84; 4.42)	0.06 (−0.24; 0.36)	−0.07 (−0.38; 0.24)	−0.06 (−0.37; 0.26)		
	Emotional function	4.90 (4.67; 5.13)	0.09 (−0.14; 0.31)	−0.11 (−0.34; 0.12)	0.05 (−0.19; 0.28)		
	Mastery	5.30 (5.05; 5.55)	0.23 (−0.02; 0.47)	−0.03 (−0.29; 0.22)	−0.12 (−0.38; 0.14)		
CCQ-I	Nr of patients	77	70	68	65		
	Symptoms	2.5 (2.12; 2.58)	−0.10 (−0.36; 0.15)	−0.06 (−0.29; 0.17)	0.03 (−0.24; 0.29)	0.30 (−0.07; 0.68)	0.14 (−0.15; 0.43)
	Functional state	2.14 (1.87; 2.41)	−0.05 (−0.29; 0.20)	0.20 (−0.05; 0.45)	0.21 (−0.05; 0.46)	0.14 (−0.22; 0.51)	0.04 (−0.27; 0.34)
	Mental state	0.93 (0.71; 1.15)	−0.13 (−0.36; 0.10)	−0.12 (−0.37; 0.14)	0.02 (−0.27; 0.30)	0 (−0.40; 0.41)	−0.05 (−0.37; 0.26)
	Total	1.81 (1.60; 2.01)	−0.10 (−0.28; 0.09)	0.01 (−0.18; 0.19)	0.09 (−0.10; 0.27)	0.16 (−0.11; 0.43)	0.04 (−0.18; 0.27)
CCQ-C	Nr of patients	74	66	61	58		
	Symptoms	2.92 (2.64; 3.21)	−0.17 (−0.43; 0.09)	−0.29 (−0.53; −0.03)	−0.28 (−0.55; 0.00)		
	Functional state	2.33 (2.03; 2.63)	0.05 (−0.20; 0.31)	0.13 (−0.13; 0.39)	0.06 (−0.20; 0.33)		
	Mental state	1.03 (0.77; 1.28)	−0.11 (−0.35; 0.12)	−0.06 (−0.33; 0.20)	0.02 (−0.28; 0.31)		
	Total	2.09 (1.87; 2.31)	−0.08 (−0.27; 0.11)	−0.07 (−0.27; 0.12)	−0.07 (−0.27; 0.13)		
HADS-I	Nr of patients	76	69	67	63		
	Anxiety	4.26 (3.41; 5.12)	−0.69 (−1.37; −0.01)	0.39 (−0.41; 1.19)	−0.24 (−0.99; 0.51)	−0.18 (−1.24; 0.89)	0.09 (−0.69; 0.88)
	Depression	3.96 (3.12; 4.80)	−0.72 (−1.32; −0.11)	0.20 (−0.56; 0.96)	−0.28 (−1.0; 0.44)	−0.26 (−1.27; 0.75)	−0.27 (−1.00; 0.51)
HADS-C	Nr of patients	76	68	63	60		
	Anxiety	5.38 (4.56; 6.21)	−0.59 (−1.3; 0.10)	−0.10 (−0.92; 0.72)	−0.07 (−0.83; 0.70)		
	Depression	5.24 (4.35; 6.12)	−0.30 (−0.91; 0.31)	0.76 (−0.02; 1.54)	−0.02 (−0.75; 0.72)		

I: COPE-active group; C: control group; CRQ: Chronic Respiratory Disease Questionnaire; CCQ: Clinical COPD Questionnaire; HADS: Hospital Anxiety and Depression Scale.
[a] Intention to treat analysis. Results were obtained with repeated measurements analysis.

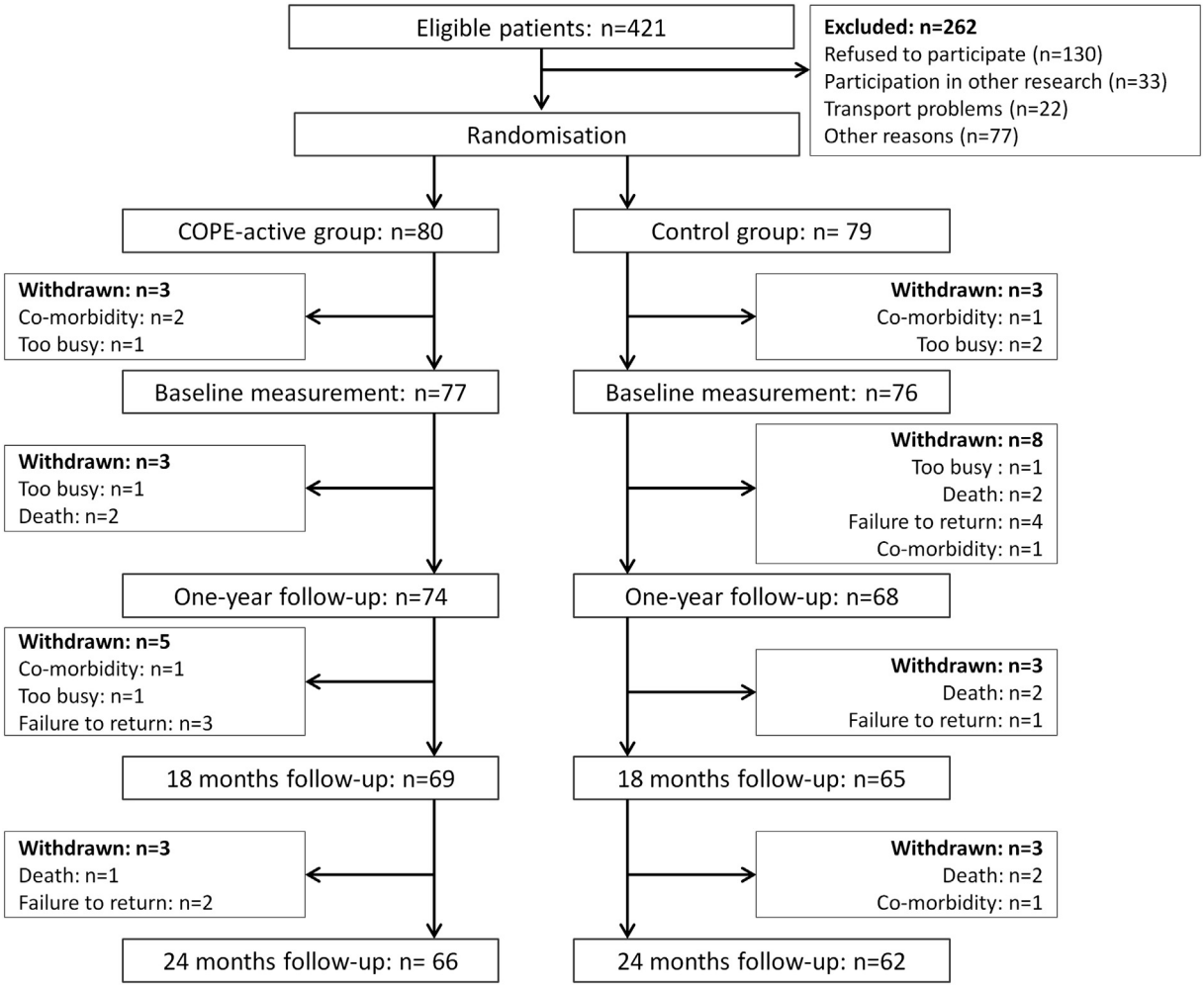

Figure 1 Patient flow during 24 months follow-up.

physiotherapy) at the end of the formal community-based exercise programme. However, the decrease in exercise capacity in the second year of follow-up suggests that most have failed to attend such programmes, or otherwise that training intensity and frequency of these programmes have been insufficient to maintain the gain in exercise capacity. Proper maintenance programmes might be preventing loss of beneficial effects after the initial exercise programme. In a systematic review of Beauchamp et al. regarding the effectiveness of supervised exercise programmes after an initial pulmonary rehabilitation programme in patients with COPD [10] only six studies could be included, and their meta-analysis showed a beneficial effect on 6MWT walking distance after six months, but after 12 months follow-up, differences between study groups were no longer statistically significant [10]. This indicates that even formal (exercise) programmes after the end of the initial programme are no guarantee for maintenance of beneficial effects. More research on the optimal maintenance programme after a primary exercise programme is therefore needed.

A crucial factor in the success of exercise interventions is adherence of patients to the programmes [28]. In our per protocol analysis on the ISWT we excluded 26 (34%) patients who participated in less than 70% of the physiotherapeutic exercise sessions and were therefore classified as non-adherent. Per protocol analyses should be interpreted with extreme care since they most likely introduce selection bias. Our per protocol analysis suggests that patients who adhered are doing better than patients who did not, however non-adherent patients were worse at baseline than adherent patients (data not shown). It therefore remains to be seen whether this is an actual effect of the intervention or a result of selection bias. The primary intention to treat analysis gives probably the most realistic look on the effectiveness of the intervention in real life, since non-adherence is part of daily practice [29].

It is interesting to note that, although the improvement in maximal exercise capacity at one year was not maintained over two years, improvement in daily physical activity as measured with a pedometer, was maintained at two years. Maximal exercise capacity is a measure of what patients are able to do, and daily physical activity is a measure of what patients actually do. So, these are two different concepts [30]. It is known that an increase in exercise capacity can already be achieved with an exercise programme as short as four weeks [31], however changes in behaviour are usually not achieved in a couple of weeks [32,33]. Our data suggests that we not only achieved a

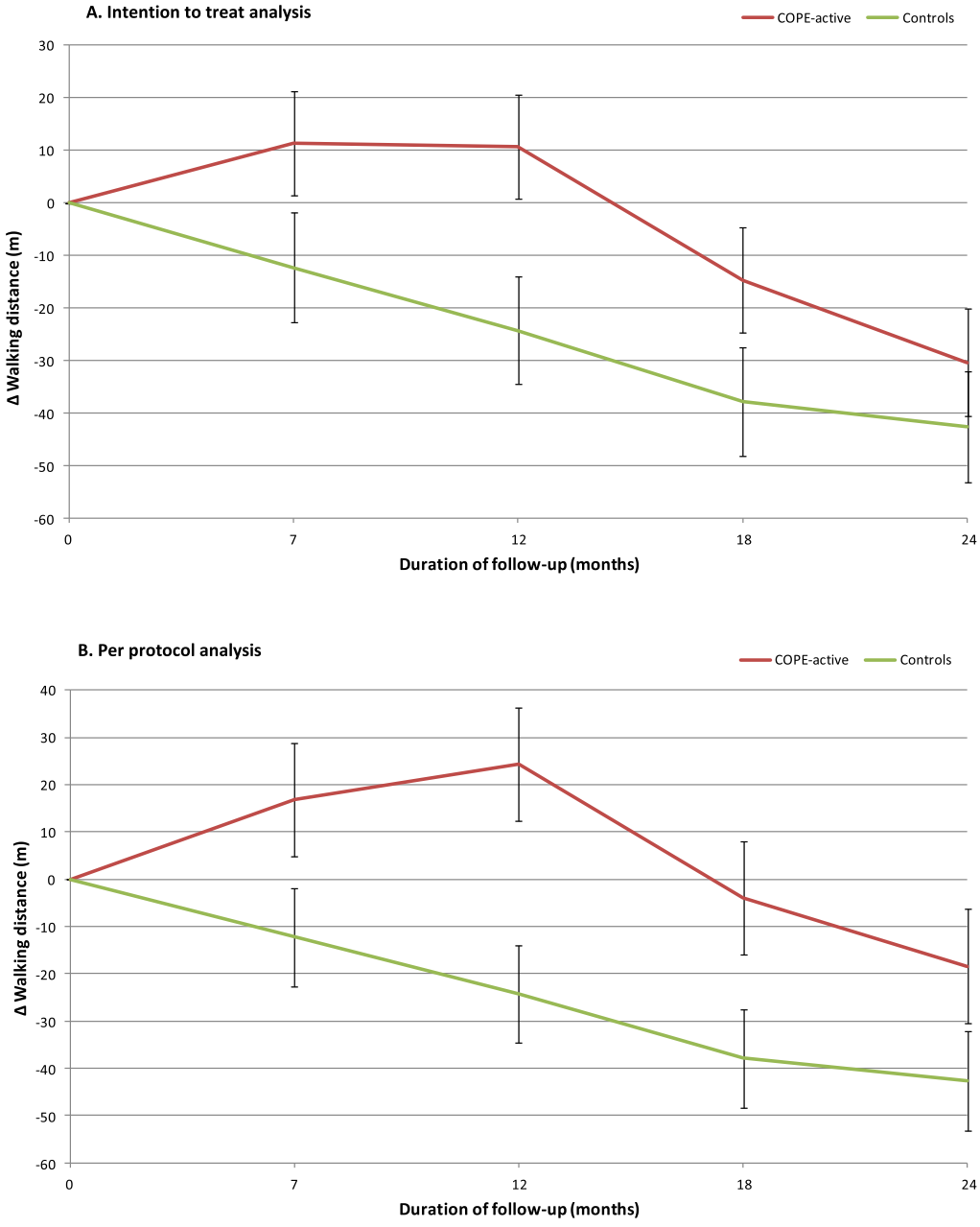

Figure 2 Mean change from baseline in incremental shuttle walk test (ISWT) walking distance over 24 months of follow-up using an intention to treat analysis (A) and a per protocol analysis (B).

change in activity behaviour, but that this effect was also maintained after two years of follow-up. However, our data also suggests that the intensity and/or frequency of this additional daily physical activity has most certainly been too low to actually contribute to maintenance of maximal exercise capacity. We were not able to assess the frequency and intensity of physical activity, since we used basic pedometers. A study that did assess walking intensity in patients with COPD concluded that 84% of the patients reached more than 30 min of walking time per day but that only less than a quarter of this time was walked at least moderate intensity [34]. In another study [33,35,36] patients were classified as regular or irregular walkers, and compared with regard to long-term maintenance of effect of a pulmonary rehabilitation programme. Both regular and irregular walkers steadily declined in 6MWT distance during 24 months follow-up [36]. These findings seem to underline that walking is not sufficient to maintain an initial increase in exercise capacity.

We used pedometers to measure daily physical activity, which can be seen as a limitation since nowadays more sophisticated activity monitors are widely available, and pedometers tend to underestimate step counts at slow walking speed [37]. Also, we had a relatively large number of missing data for daily physical activity. Despite great efforts of the research personnel, there were issues with pedometers that did not work (either due to low battery or mechanical defects), patients not returning the pedometer

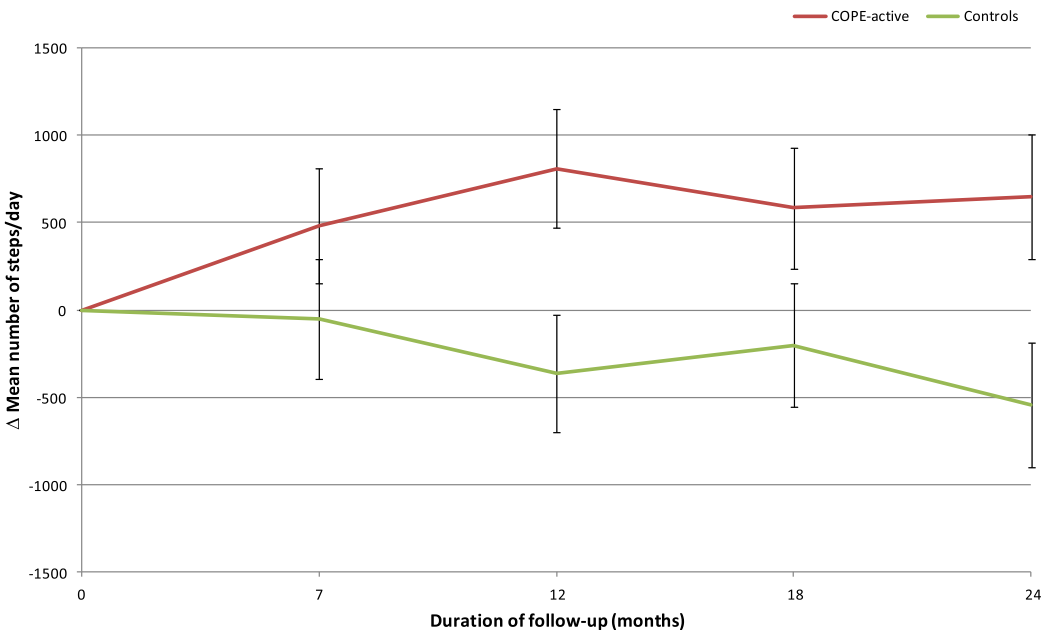

Figure 3 Mean change from baseline in daily physical activity (mean number of steps/day) over 24 months of follow-up using an intention to treat analysis.

and diary, or patients just not wearing the pedometer for seven days. In general, patients who did not have a pedometer measurement at 24 months follow-up seemed to have a worse functional state at baseline compared to the patients who had a measurement. Possible underestimation due to the use of pedometers or overestimation due to the relatively large amount of missing data would be expected to be the same in both groups, and would therefore not have affected the between-group difference.

A statistically significant between-group difference was found on the CRQ-dyspnoea domain, indicating that patients who participated in the COPE-active programme experienced less dyspnoea during activities than patients in the control group [23]. Breathing exercises and coping with breathlessness were part of the initial self-management programme, but patients in the intervention group had multiple opportunities to practice and acquire these methods during exercise under supervision of a physiotherapist. Also, improved exercise tolerance in the intervention group might have led to a reduction in exertional dyspnoea during activities which in turn might have contributed to the increase in daily physical activity [38]. As was expected based on the 12-month results, we did not find any between-group differences on the other CRQ domains or the CCQ. This is probably due to the already relatively good scores at baseline which left little room for improvement during follow up [15]. The same accounts for anxiety and depression measured with the HADS.

We had already shown that in comparison to a self-management programme only, a community-based physiotherapeutic exercise programme was effective in achieving a behavioural change reflected by an increase in daily physical activity after one year. We now show that the increase in daily physical activity could be maintained over the second year, but not the increase in exercise capacity. We still need further studies investigating how an initial increase in exercise capacity can be best maintained.

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Conflict of interest statement

There are no conflicts of interest.

References

[1] Spruit MA, Singh SJ, Garvey C, Zuwallack R, Nici L, Rochester C, et al. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. Am J Respir Crit Care Med 2013 Oct 15;188(8):e13—64.

[2] Pitta F, Troosters T, Spruit MA, Probst VS, Decramer M, Gosselink R. Characteristics of physical activities in daily life in chronic obstructive pulmonary disease. Am J Respir Crit Care Med 2005 May 1;171(9):972—7.

[3] Troosters T, Sciurba F, Battaglia S, Langer D, Valluri SR, Martino L, et al. Physical inactivity in patients with COPD, a controlled multi-center pilot-study. Respir Med 2010 Jul;104(7):1005—11.

[4] Watz H, Waschki B, Meyer T, Magnussen H. Physical activity in patients with COPD. Eur Respir J 2009 Feb;33(2):262—72.

[5] Lacasse Y, Martin S, Lasserson TJ, Goldstein RS. Meta-analysis of respiratory rehabilitation in chronic obstructive pulmonary disease. A Cochrane systematic review. Eura Medicophys 2007 Dec;43(4):475—85.

[6] Troosters T, Gosselink R, Decramer M. Short- and long-term effects of outpatient rehabilitation in patients with chronic

obstructive pulmonary disease: a randomized trial. Am J Med 2000 Aug 15;109(3):207—12.
[7] Guell R, Casan P, Belda J, Sangenis M, Morante F, Guyatt GH, et al. Long-term effects of outpatient rehabilitation of COPD: a randomized trial. Chest 2000 Apr;117(4):976—83.
[8] Griffiths TL, Burr ML, Campbell IA, Lewis-Jenkins V, Mullins J, Shiels K, et al. Results at 1 year of outpatient multidisciplinary pulmonary rehabilitation: a randomised controlled trial. Lancet 2000 Jan 29;355(9201):362—8.
[9] Bestall JC, Paul EA, Garrod R, Garnham R, Jones RW, Wedzicha AJ. Longitudinal trends in exercise capacity and health status after pulmonary rehabilitation in patients with COPD. Respir Med 2003 Feb;97(2):173—80.
[10] Beauchamp MK, Evans R, Janaudis-Ferreira T, Goldstein RS, Brooks D. Systematic review of supervised exercise programs after pulmonary rehabilitation in individuals with COPD. Chest 2013 Oct;144(4):1124—33.
[11] Spruit MA, Singh SJ. Maintenance programs after pulmonary rehabilitation: how may we advance this field? Chest 2013 Oct;144(4):1091—3.
[12] Effing TW, Bourbeau J, Vercoulen J, Apter AJ, Coultas D, Meek P, et al. Self-management programmes for COPD: moving forward. Chron Respir Dis 2012 Feb;9(1):27—35.
[13] Bourbeau J, van der Palen J. Promoting effective self-management programmes to improve COPD. Eur Respir J 2009 Mar;33(3):461—3.
[14] Effing T, Monninkhof EM, van der Valk PD, van der Palen J, van Herwaarden CL, Partidge MR, et al. Self-management education for patients with chronic obstructive pulmonary disease. Cochrane Database Syst Rev 2007;(4):CD002990.
[15] Effing T, Zielhuis G, Kerstjens H, van der Valk P, van der Palen J. Community based physiotherapeutic exercise in COPD self-management: a randomised controlled trial. Respir Med 2011 Mar;105(3):418—26.
[16] Effing T, Kerstjens H, van der Valk P, Zielhuis G, van der Palen J. (Cost)-effectiveness of self-treatment of exacerbations on the severity of exacerbations in patients with COPD: the COPE II study. Thorax 2009 Nov;64(11):956—62.
[17] Altman DG, Bland JM. Treatment allocation by minimisation. BMJ 2005 Apr 9;330(7495):843.
[18] Rabe KF, Hurd S, Anzueto A, Barnes PJ, Buist SA, Calverley P, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. Am J Respir Crit Care Med 2007 Sep 15;176(6):532—55.
[19] Singh SJ, Morgan MD, Scott S, Walters D, Hardman AE. Development of a shuttle walking test of disability in patients with chronic airways obstruction. Thorax 1992 Dec;47(12):1019—24.
[20] Singh SJ, Jones PW, Evans R, Morgan MD. Minimum clinically important improvement for the incremental shuttle walking test. Thorax 2008 Sep;63(9):775—7.
[21] Revill SM, Morgan MD, Singh SJ, Williams J, Hardman AE. The endurance shuttle walk: a new field test for the assessment of endurance capacity in chronic obstructive pulmonary disease. Thorax 1999 Mar;54(3):213—22.
[22] Puhan MA, Behnke M, Laschke M, Lichtenschopf A, Brandli O, Guyatt GH, et al. Self-administration and standardisation of the chronic respiratory questionnaire: a randomised trial in three German-speaking countries. Respir Med 2004 Apr;98(4):342—50.
[23] Juniper EF, Guyatt GH, Willan A, Griffith LE. Determining a minimal important change in a disease-specific quality of life questionnaire. J Clin Epidemiol 1994 Jan;47(1):81—7.
[24] van der Molen T, Willemse BW, Schokker S, ten Hacken NH, Postma DS, Juniper EF. Development, validity and responsiveness of the clinical COPD questionnaire. Health Qual Life Outcomes 2003;1:13.
[25] Kocks JW, Tuinenga MG, Uil SM, van den Berg JW, Stahl E, van der Molen T. Health status measurement in COPD: the minimal clinically important difference of the clinical COPD questionnaire. Respir Res 2006;7:62.
[26] Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand 1983 Jun;67(6):361—70.
[27] Donaldson GC, Seemungal TA, Bhowmik A, Wedzicha JA. Relationship between exacerbation frequency and lung function decline in chronic obstructive pulmonary disease. Thorax 2002 Oct;57(10):847—52.
[28] Nici L. Adherence to a pulmonary rehabilitation program: start by understanding the patient. COPD 2012 Aug;9(5):445—6.
[29] Hogg L, Garrod R, Thornton H, McDonnell L, Bellas H, White P. Effectiveness, attendance, and completion of an integrated, system-wide pulmonary rehabilitation service for COPD: prospective observational study. COPD 2012 Aug;9(5):546—54.
[30] Larson JL. Functional performance and physical activity in chronic obstructive pulmonary disease: theoretical perspectives. COPD 2007 Sep;4(3):237—42.
[31] Sewell L, Singh SJ, Williams JE, Collier R, Morgan MD. How long should outpatient pulmonary rehabilitation be? A randomised controlled trial of 4 weeks versus 7 weeks. Thorax 2006 Sep;61(9):767—71.
[32] Wempe JB, Wijkstra PJ. The influence of rehabilitation on behaviour modification in COPD. Patient Educ Couns 2004 Mar;52(3):237—41.
[33] Bourbeau J, Nault D, Dang-Tan T. Self-management and behaviour modification in COPD. Patient Educ Couns 2004 Mar;52(3):271—7.
[34] Vitorasso R, Camillo CA, Cavalheri V, Aparecida HN, Cortez VA, Sant'Anna T, et al. Is walking in daily life a moderate intensity activity in patients with chronic obstructive pulmonary disease? Eur J Phys Rehabil Med 2012 Dec;48(4):587—92.
[35] Ries AL, Kaplan RM, Myers R, Prewitt LM. Maintenance after pulmonary rehabilitation in chronic lung disease: a randomized trial. Am J Respir Crit Care Med 2003 Mar 15;167(6):880—8.
[36] Heppner PS, Morgan C, Kaplan RM, Ries AL. Regular walking and long-term maintenance of outcomes after pulmonary rehabilitation. J Cardiopulm Rehabil 2006 Jan;26(1):44—53.
[37] Turner LJ, Houchen L, Williams J, Singh SJ. Reliability of pedometers to measure step counts in patients with chronic respiratory disease. J Cardiopulm Rehabil Prev 2012 Sep;32(5):284—91.
[38] Parshall MB, Schwartzstein RM, Adams L, Banzett RB, Manning HL, Bourbeau J, et al. An official American Thoracic Society statement: update on the mechanisms, assessment, and management of dyspnea. Am J Respir Crit Care Med 2012 Feb 15;185(4):435—52.