

The COPD assessment test (CAT) – response to pulmonary rehabilitation. A multicentre, prospective study.

James W Dodd¹, Lauren Hogg², Jane Nolan¹, Helen Jefford³, Amy Grant⁴, Victoria M Lord⁵, Christine Falzon⁶, Rachel Garrod⁷, Cassandra Lee⁸, Michael I Polkey⁵, Paul W Jones¹, William D-C Man⁵, Nicholas S Hopkinson⁵.

¹St George's Hospital NHS Trust, London, UK

²Guy's and St Thomas' Foundation NHS Trust, London, UK

³Greenwich Primary Care Trust, London, UK

⁴Croydon Primary Care Trust, London, UK

⁵The NIHR Respiratory Biomedical Research Unit, Royal Brompton & Harefield NHS Foundation Trust and Imperial College, London UK.

⁶Central London Community Healthcare, London, UK

⁷King's College Hospital NHS Foundation Trust

⁸Imperial College Healthcare NHS Trust

Corresponding Author: Nicholas Hopkinson, The NIHR Respiratory Biomedical Research Unit, Royal Brompton & Harefield NHS Foundation Trust and Imperial College, London

Royal Brompton Hospital

Fulham Rd

London UK.

n.hopkinson@ic.ac.uk Tel 02073497775 Fax 02073497778

Key words: Quality of life, minimal clinically important difference, COPD

Word Count: 2894

What is the key question? Does the COPD assessment test (CAT), a new health status measure for the condition, show a response to pulmonary rehabilitation?

What is the bottom line? A fall (improvement) in the score occurs following pulmonary rehabilitation which was larger in those who felt “much better” rather than in those who felt only “a little better”.

Why read on? The article compares response to the CAT, which is simple to implement and score, to response to other outcome measures currently in use for pulmonary rehabilitation.

ABSTRACT

Background: The COPD assessment test (CAT) is a recently introduced, simple to use patient-completed quality of life instrument that contains 8 questions covering the impact of symptoms in COPD. It is not known how the CAT score performs in the context of clinical pulmonary rehabilitation (PR) programs or what the minimum clinically important difference is.

Methods: We prospectively studied the introduction of the CAT score as an outcome measure by PR programs across London. It was used alongside other measures including the St George's Respiratory Questionnaire, The Chronic Respiratory Disease Questionnaire, The Clinical COPD Questionnaire, The Hospital Anxiety and Depression Score, The MRC dyspnoea score and a range of different walking tests. Patients completed a 5 point anchor question used to assess overall response to PR from "I feel much better" to "I feel much worse".

Results: Data was available for 261 COPD patients participating in 7 programs, Mean(SD) age 69.0(9.0) years, FEV₁ 51.1(18.7)% predicted, MRC score 3.2(1.0). Mean change in CAT score after PR was 2.9(5.6) points, improving by 3.8(6.1) points in those scoring "much better" (n=162), and by 1.3(4.5) in those who felt "a little better" (n=88) (p=0.002). Only 8 individuals reported no difference after PR and 3 reported feeling "a little worse" so comparison with these smaller groups was not possible.

Conclusion: The CAT score is simple to implement as an outcome measure, it improves in response to PR and can distinguish categories of response.

INTRODUCTION

In patients with chronic obstructive pulmonary disease (COPD) pulmonary rehabilitation (PR) can reduce symptoms, improve activity, restore independent function and reduce health care utilisation.[1-3] Validated tools including the St George's Respiratory Questionnaire (SGRQ),[4] Chronic Respiratory Questionnaire (CRQ)[5] and Clinical COPD Questionnaire (CCQ)[6] have been used to assess the impact of PR on health related quality of life (HRQOL). However current health-related quality of life questionnaires are complex, time consuming to complete and may require specialist software or licenses to use, which limits their applicability in routine practice.

The COPD Assessment Test (CAT)[7] was developed as a short, simple instrument for quantifying the symptom burden of (COPD) in routine practice to aid health status assessment and facilitate communication between patient and health care professionals. It consists of 8 items, each presented as a semantic six-point differential scale, providing a score out of 40 indicating the impact of the disease. It is completed by the patient and the result is immediately available without the need for any calculation, apart from summing the scores on individual items. Scores of 0-10, 11-20, 21-30, 31-40 represent mild, moderate, severe or very severe clinical impact.[8]

The CAT was derived from 21 candidate items identified through qualitative research with COPD patients from three prospective international studies (Europe and the USA, n=1,503). Psychometric and Rasch analyses identified eight items fitting a

unidimensional model to form the CAT, with high internal consistency (Cronbach's α was 0.88). Intra-class correlation coefficient was 0.8 for test re-test in stable patients and CAT score correlated well with the COPD-specific version of the St George's Respiratory Questionnaire (r 0.80). There is data to show that it distinguishes stable from exacerbating patients[7] but as yet no data on how it responds to pulmonary rehabilitation or any other intervention.

Pulmonary rehabilitation programs routinely use various methods to collect data about patients' baseline characteristics including health status and to assess their response to rehabilitation. The adoption of the CAT as an outcome measure by a network of pulmonary rehabilitation centres around London, provided the opportunity to evaluate its responsiveness relative to other outcome measures used in rehabilitation studies and explore the use an anchor questionnaire to address the minimum clinically important difference for the CAT.

METHODS

We performed a multi-centre, prospective study of response to pulmonary rehabilitation in patients with a clinical diagnosis of COPD. The study was approved by the Riverside Research Ethics Committee and recorded on an international trials register - ISRCTN51185878. Participating sites were located throughout London in both primary and secondary care settings. Patients were referred into programmes by a medical practitioner. All programs included a mixture of aerobic and strength training and a mixture of supervised sessions and unsupervised home exercise, usually two supervised and one or more home sessions per week, with a duration of

eight weeks. Initial exercise prescription was based on the outcome of a baseline walking test and workloads were increased through the program as tolerated. Programs were multidisciplinary with an educational component covering issues including exercise, medication use, diet and coping strategies. Data was collected between January and August 2010 and recorded at enrolment and completion of the programs.

The primary objective of the study was to establish the change in CAT score occurring in response to pulmonary rehabilitation, relating this to an anchor question to explore CAT scores that may be indicative of the minimum clinically important difference (MCID). Response to the anchor question used to assess overall response to rehabilitation, “How do you feel your overall condition has changed after rehabilitation?” was scored; 1 “I feel much better” 2 “I feel a little better”, 3 “I feel no different”, 4 “I feel a little worse”, 5 “I feel much worse”. The anchor question was asked at the end of the final assessment session.

Secondary objectives were to compare baseline CAT and change in CAT score with other health status and functional parameters measured in rehabilitation and to measure effect size of the tests being evaluated. The programs in this study used a range of different baseline measures and outcomes and the use of some outcomes varied between sites within programs, so that the sample size for comparing the CAT to other measures was variable.

Description of other comparator outcome measures used

The Clinical COPD Questionnaire (CCQ)[6] is a self-administered questionnaire developed to measure clinical control in patients with COPD. It includes ten items; each response is graded 1-6 with a higher score indicating worse health status. Cronbach's alpha is high (0.91). Significant correlations have been demonstrated between the CCQ total score and domains of the SGRQ ($r=0.67$ to $r=0.72$). In patients with COPD, the correlation between the CCQ and FEV₁% predicted was $r = -0.49$. Test retest reliability is high (Intra Class Coefficient = 0.94). The minimum clinically important difference of the CCQ is 0.4.[9]

The St George's Respiratory Questionnaire (SGRQ)[4] consists of 50 items with 76 weighted responses. It was developed and validated in both asthma and COPD. It is completed by the patient by hand but requires a computer to score it. Scores are calculated for three domains: Symptoms, activity and impacts (psycho-social) as well as a total score. Psychometric testing has demonstrated its repeatability, reliability and validity. Scores range from 0-100, with a higher score indicating worse health status. A minimum change in score of 4 units was established as clinically relevant after patient and clinician testing. The SGRQ correlates significantly with other measures of disease activity such as cough, dyspnoea, 6-min walk test and FEV₁ as well as other measures of general health such as the SIP and SF36.

The Chronic Respiratory Disease Questionnaire (CRQ)[5] is a self reported questionnaire developed to determine the effect of treatment on quality of life in clinical trials. It consists of four dimensions: dyspnoea, fatigue, emotional function, and the patient's feeling of control over the disease (mastery). Reproducibility, tested by repeated administration to patients in a stable condition, has been excellent: the

coefficient of variation was less than 12% for all four dimensions. An MCID has been determined as 0.5 for each of the mean domain scores of the chronic respiratory questionnaire.[10]

The incremental shuttle walking test ISWT (ISWT) uses a 10m course and the walking speed is externally paced by signals from an audio cassette or CD. The patient is required to walk between two cones in time to a set of auditory beeps. [11] The patient walks for as long as they can until they are either too breathless or can no longer keep up with the beeps at which time the test ends. The number of shuttles (laps between the cones) is recorded. The results of the ISWT can be used to prescribe the intensity of walking exercise. Following pulmonary rehabilitation in patients with COPD, an improvement of 47.5 metres in ISWT corresponded with a patient perception that their exercise performance was 'slightly better' and an improvement of 78.7 metres corresponded with 'better'. [12]

Endurance Shuttle Walk Test (ESWT)[13] is a standardised field test for the assessment of endurance capacity in patients with chronic lung disease. The test was developed as an adjunct to the ISWT so that together they form a practical method of assessing both functional and endurance exercise capacity using the same 10m shuttle course.

The 6 minute walk test (6MWT) is a self paced test that measures the distance that a patient can quickly walk in a period of 6 minutes (the 6MWD).[14] Verbal Instructions are standardised. Optimal reference equations from healthy population-based samples using standardised 6MWT methods have recently become available and a

walking distance in excess of 500m is typical for patients of a comparable age to those entering PR [15].

Statistics and data analysis

The data were anonymised at each site and collated centrally for analysis using SPSS v18. Paired t tests were used for comparison of CAT score pre and post rehabilitation sessions. Univariate analysis of variance was used for each anchor question response. Correlation between change in CAT and other measures of health status and disease severity were calculated using Pearson correlations and linear regression tools, significantly skewed data was log transformed before analysis. Effect size was calculated as the mean difference in values before and after pulmonary rehabilitation divided by the mean SD (i.e. mean SD at baseline and follow up). It therefore expresses the change in response to treatment against the variability of the parameter in the population being studied. Data are presented as mean \pm standard deviation unless otherwise specified and a p value of <0.05 taken as significant.

RESULTS

Data on CAT score before and after pulmonary rehabilitation was available for 297 individuals, age 69.2 ± 9.3 , 62.7% male, FEV₁ 50.9 ± 18.9 (percent predicted), MRC dyspnoea score 3.4 ± 1.0 . BMI median 27.7 ± 6.5 . In response to the anchor question 162 reported they were much better after PR, 88 a little better, 8 no different and 3 a little worse. In 36 cases the anchor question was not completed. The group in whom the anchor question was not documented did not differ significantly from those in

whom it had been recorded. Although not therefore available for the primary outcome, data from these 36 cases was retained for other analyses. Location, recruitment figures and outcome measures used at different sites are given in table 1.

Baseline CAT score correlated in univariate analysis with other health status measures, MRC score, ISWT distance, age and airflow obstruction as expected, with a higher CAT score associated with worse breathlessness, anxiety, depression and functional exercise capacity (Table 2). CAT score was lower in men 19.7 ± 7.2 vs 21.5 ± 7.5 ($p=0.03$). In a stepwise regression analysis including age, MRC dyspnoea score, BMI, gender and FEV₁ percent predicted (n=178 with these data available) only age and MRC dyspnoea score were retained giving an equation; CAT score = $18.8 + 3.9(\text{MRC score}) - 0.16(\text{age})$ (r^2 0.29).

Table 1 Participating centres and outcome measures employed

Name of participating centre	Number of patients	Outcome measures
Royal Brompton and Harefield Foundation NHS Trust	87	SGRQ, ISWT, ESWT, HAD, MRC, CRQ
St George's Hospital NHS Trust	22	ISWT, SGRQ
Kings Health Partners/Guy's and St Thomas' Foundation NHS Trust	66	6MWT, ISWT, CRQ, HAD, MRC
Greenwich PCT	57	6MWT, CCQ
Kensington and Chelsea PCT	11	ISWT, ESWT, CRQ, HAD
Croydon PCT	34	ISWT, CRQ, HAD
Westminster PCT	17	ESWT, CRQ, HAD, MRC

SGRQ - St George's Respiratory Questionnaire; ISWT – Incremental shuttle walk test; ESWT - endurance shuttle walk test; PCT Primary care trust; MRC – Medical Research Council dyspnoea score; CRQ – chronic respiratory questionnaire; CCQ – clinical COPD questionnaire; HAD – hospital anxiety and depression score.

Table 2 Univariate correlates of baseline CAT score.

Variable	Correlation efficient	co- Number of observations	P value
Age	0.24	296	<0.001
FEV ₁ %pred	-0.17	239	0.008
MRC dyspnoea score	0.44	252	<0.001
HAD A	0.37	215	<0.001
HAD D	0.36	215	<0.001
CCQ	0.68	58	<0.001
CRQTotal	-0.33	297	<0.001
SGRQTotal	0.74	38	<0.001
ISWT	-0.36	211	<0.001
6MWT	-0.27	68	0.03
lnESWT	-0.28	38	0.084

FEV₁%pred Forced expiratory volume in 1 second % predicted; SGRQ - St George's Respiratory Questionnaire; ISWT – Incremental shuttle walk test; lnESWT – log transformed endurance shuttle walk test; MRC – Medical Research Council dyspnoea score; CRQ – chronic respiratory questionnaire; CCQ – clinical COPD questionnaire; HAD – hospital anxiety and depression score.

The response of the various outcome measures to rehabilitation are given in Table 3 together with estimation of effect size. The CAT improved significantly following rehabilitation -2.9 ± 5.6 ($p < 0.001$), as did all other measures of health status and functional capacity. The effect size of rehabilitation on CAT score was moderate ($d = 0.4$), other health status measure effect sizes were variable (CCQ 0.6 and CRQ 0.8, SGRQ 0.2) although the numbers completing each measure were variable; for example the SGRQ was used in only 39 participants which means that direct comparisons require caution.

Change in CAT score in response to rehabilitation was independently associated with baseline CAT score, falling most in those with the highest baseline symptom burden ($r = -0.34$ $p < 0.0001$). The score also improved more in women; Δ CAT -3.8 ± 6.1 vs -2.2 ± 5.3 ($p = 0.019$), but was not associated with baseline dyspnoea, anxiety and depression, walking distance or airflow obstruction.

Change in CAT score following pulmonary rehabilitation correlated significantly with changes in other measures of response to pulmonary rehabilitation (Table 4). Figure 1 shows the correlation between the change in the most frequently recorded measure of health status (the CRQ total score, $n = 195$) and Δ CAT score following pulmonary rehabilitation.

Table 3: Response to pulmonary rehabilitation

	Pre PR	Post PR	Change	p value	Effect size (d)
CAT (n=297)	20.5 ± 7.4	17.5 ± 7.7	-2.9 ± 5.6	<0.001	0.4
HAD - anxiety (n=211)	7.3 ± 4.2	6.1 ± 4.1	-1.3 ± 3.3	<0.001	0.3
HAD - depression (n=211)	6.7 ± 3.6	5.2 ± 3.2	-1.5 ± 3.0	<0.001	0.4
CRQ Total (n=195)	14.9 ± 4.1	18.2 ± 4.2	3.3 ± 3.8	<0.001	-0.8
ISWT (m) (n=191)	238 ± 148	309 ± 175	70 ± 83	<0.001	-0.4
MRC dyspnoea score (n=130)	3.4 ± 1.0	2.9 ± 1.1	-0.6 ± 0.7	<0.001	0.6
6MWT (m) (n=68)	267 ± 94	339 ± 105	72 ± 74	<0.001	-0.7
CCQ (n=57)	3.0 ± 1.2	2.3 ± 1.3	-0.7 ± 0.9	<0.001	0.6
SGRQ-Total (n=39)	45.7 ± 19.4	41.8 ± 17.2	-3.9 ± 9.0	<0.001	0.2
ESWT (s) (n=36)	294 ± 215	502 ± 393	208 ± 47	0.001	-0.7

Measures are presented in order of frequency with which they were measured. SGRQ - St George's Respiratory Questionnaire; ISWT – Incremental shuttle walk test; ESWT - endurance shuttle walk test; MRC – Medical Research Council dyspnoea score; CRQ – chronic respiratory questionnaire; CCQ – clinical COPD questionnaire; HAD – hospital anxiety and depression score. p values are for paired t tests.

Table 4 Univariate correlates of change in CAT score.

Variable	Correlation efficient	co- Number observations	of P value
ΔCRQ total	-0.41	195	<0.001
ΔSGRQ total	0.36	38	0.03
ΔCCQ	0.13	57	0.034
ΔHAD Anxiety	0.15	210	0.03
ΔHAD Depression	0.17	211	0.01
ΔISWT	-0.19	191	0.008
Δ6MWT	0.31	68	0.01
ΔlnESWT	-0.19	27	0.35
ΔMRC	0.20	130	0.02

SGRQ - St George's Respiratory Questionnaire; ISWT – Incremental shuttle walk test; lnESWT – log transformed endurance shuttle walk test; MRC – Medical Research Council dyspnoea score; CRQ – chronic respiratory questionnaire; CCQ – clinical COPD questionnaire; HAD – hospital anxiety and depression score.

The data in table 5 shows the change in CAT and other outcome measures following pulmonary rehabilitation according to the different anchor response categories. Change in CAT score was sensitive to different levels of response to the anchor question (-3.8 ± 6.1 “much better”; -1.3 ± 4.5 “a little better” $p=0.002$) (Figure 2). Only small numbers were available for the response categories “no different” $n=8$ Δ CAT -2.3 ± 3.3 ; and “a little worse” $n=3$ Δ CAT $+2 \pm 0$.

Table 5 shows that in addition to change in CAT score, change in CRQ and HAD scores also differed significantly across anchor responses.

Table 5: Change in outcome measure by Anchor question response

	“Much better”	“A Little better”	”No different”	“a little worse”	p value
Δ CAT	-3.8 ± 6.1 n=162	-1.3 ± 4.5 n=88	-1.1 ± 3.4 n=8	2.0 ± 0 n=3	0.002
Δ HAD Anx	-1.5 ± 3.2 n=109	-1.0 ± 3.0 n=61	2.0 ± 2.6 n=7	1.7 ± 3.2 n=3	0.04
ΔHAD Dep	-1.6 ± 3.0 n=110	-1.5 ± 2.6 n=61	-1.7 ± 3.0 n=7	1.3 ± 0.6 n=3	0.03
Δ CRQ Total	3.8 ± 3.7 n=103	2.3 ± 3.9 n=53	-0.8 ± 2.1 n=6	-2.7 ± 1.4 n=2	0.005
Δ ISWT	77.8 ± 72.4 n=108	45.7 ± 75.7 n=53	54.0 ± 89.3 n=10	33.3 ± 106.9 n=3	0.009*
Δ MRC score	-0.6 ± 0.7 n=81	-0.5 ± 0.8 n=39	-0.3 ± 0.4 n=8	-	ns*
Δ CCQ	-0.7 ± 1.1 n=36	-0.7 ± 0.6 n=19	0.7 n=1	-	ns*
Δ 6MWD	86.9 ± 83.1 n=42	44.6 ± 48.5 n=22	80 n=1	-	ns*
Δ SGRQ total	-3.3 ± 8.8 n=21	-3.1 ± 8.2 n=14	-13 ± 18.4 n=2	-	ns*

Measures are presented in order of frequency with which they were documented.

SGRQ - St George’s Respiratory Questionnaire; ISWT – Incremental shuttle walk test; ESWT - endurance shuttle walk test; MRC – Medical Research Council dyspnoea score; CRQ – chronic respiratory questionnaire; CCQ – clinical COPD

questionnaire; HAD – hospital anxiety and depression score. p values are for ANOVA except *Kruskal Wallis test.

DISCUSSION

The main findings of the present study are that the CAT score is responsive to pulmonary rehabilitation and can discriminate between different levels of subjective response when compared to an anchor question, with a fall of 1.3 points corresponding to “a little better” and 3.8 points to “much better.” It correlated with improvements in other outcome measures and the estimated effect size of pulmonary rehabilitation on change in CAT was moderate.

Methodological issues

A strength of this study is that it included a relatively large sample of unselected patients taking part in clinical pulmonary rehabilitation programs with data collected prospectively across multiple sites. As such it is likely to be generalisable to routine clinical practice. The centres participating added the CAT score alongside the data they were already collecting routinely, which meant that not all patients had all outcomes measured. Caution is therefore needed in comparing the different measures, as sample sizes available for the comparisons vary. In particular the sample size for the SGRQ is small.

The MCID for the CAT has not yet been established. Based on a mapping exercise with the published data comparing the CAT and SGRQ [7], the 4-unit MCID for the SGRQ corresponds to a value of 1.6 units for the CAT MCID. An objective of this study was to provide further data that might contribute to the CAT MCID estimation

process, but the effectiveness of pulmonary rehabilitation meant that the full range of the anchor question responses 1-5 was not used. This type of one-direction change limits the reliability of MCID estimates, however the change of 1.3 units observed in the 53 patients who reported that they were “a little better” is of a similar magnitude to the change in CAT score that corresponds to the SGRQ MCID. An alternative approach is to use the MCID of another validated and repeatable clinical measure such as the CRQ as an anchor for those that respond to pulmonary rehabilitation. This technique has been used previously when estimating MCID for exercise tests in COPD.[16] However the use of linear regression in this way assumes no measurement error [17] and its reliability is dependent upon the strength of correlation between the two measurements, which in the case of the CRQ was only 0.4 (Fig 1).

Significance of findings

The data suggest that the CAT score can be used as an outcome measure in COPD patients taking part in pulmonary rehabilitation. Since the tool is quick to complete and score and can therefore be integrated into routine clinical practice it offers the possibility of a closer integration between PR and other aspects of care. The CAT can be completed by patients online, which may be of use in the home management and maintenance of rehabilitation. We acknowledge that certain tools used for baseline assessment may provide specific information that will influence clinical practice, for example the HAD score may guide referral for psychological support and the lung information needs questionnaire (LINQ) might identify individuals who need particular attention to their understanding of their disease.[18 19] A significant amount of time and effort is required by both patients and health professionals in the

completion and scoring of various outcome measures around PR, which has an opportunity cost for the delivery of the PR intervention itself. Given the resource limitations that exist, the widespread introduction of a simpler tool such as the CAT may have significant cost benefits.

An important observation is that the overall effectiveness of pulmonary rehabilitation in the programs in this study was similar to that outlined in a recent meta analysis of clinical trials of pulmonary rehabilitation, where improvements in CRQ (0.77-1.1), SGRQ (-6.1) exceeded their respective MCID's.[2] This suggests that outcomes achieved in routine clinical practice are comparable to those observed in clinical trials, at least in patients completing the program. In our study the participants exceeded the MCID for the CRQ, the 6MWT and the ISWT (Table 3).[10 12 16] In fact the effectiveness of pulmonary rehabilitation meant that the full range of the anchor question responses 1-5 was not used - only 8 (3%) subjects reported no improvement and 3 (1%) that they were a little worse. This may appear to differ from the results of Singh *et al* who found a wider range of responses when they assessed the MCID for the ISWT, but it should be noted that the anchor question in that study addressed exercise capacity specifically rather than the more general question in the present paper "How do you feel your overall condition has changed after rehabilitation?".[12]

Conclusion: The CAT score is responsive to pulmonary rehabilitation and able to distinguish different levels of response. Widespread adoption of the CAT as a substitute for more time-consuming questionnaires has the potential to streamline PR provision and improve benchmarking between programs.

SUPPORTED BY

The NIHR Respiratory Biomedical Research Unit Royal Brompton & Harefield NHS Foundation Trust and Imperial College.

ACKNOWLEDGMENTS

The authors would like to acknowledge the following for their assistance in collecting data; Karen Ingram, Ria Fowler and Amy Clark at Harefield Hospital; Hellene Bellas at King's College Hospital.

COMPETING INTERESTS

The authors have no conflicts of interest to declare.

FUNDING

Supported by: The NIHR Respiratory Biomedical Research Unit Royal Brompton & Harefield NHS Foundation Trust and Imperial College. WD-CM is funded by a NIHR Clinician Scientist award. The views expressed in this publication are those of the authors and not necessarily those of the NHS, The National Institute for Health Research nor the Department of Health. NSH is a HEFCE clinical Senior Lecturer

COPYRIGHT LICENSING STATEMENT

The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, an exclusive licence (or non exclusive for government employees) on a worldwide basis to the BMJ Publishing Group Ltd and its Licensees to permit this article (if accepted) to be published in [THORAX] editions and any other BMJPG Ltd products to exploit all subsidiary rights, as set out in our licence

<http://thorax.bmj.com/site/about/licence.pdf>

REFERENCES

1. Nici L, Donner C, Wouters E, et al. American Thoracic Society/European Respiratory Society Statement on Pulmonary Rehabilitation. *Am. J. Respir. Crit. Care Med.* 2006;173:1390-1413.
2. Lacasse Y, Goldstein R, Lasserson TJ, et al. Pulmonary rehabilitation for chronic obstructive pulmonary disease. *Cochrane Database Syst Rev.* 2006:CD003793.
3. Seymour JM, Moore L, Jolley CJ, et al. Outpatient pulmonary rehabilitation following acute exacerbations of COPD. *Thorax.* 2010;65:423-428.
4. Jones PW, Quirk FH, Baveystock CM, et al. A self-complete measure of health status for chronic airflow limitation. The St. George's Respiratory Questionnaire. *Am Rev Respir Dis.* 1992;145:1321-7.
5. Guyatt GH, Berman LB, Townsend M, et al. A measure of quality of life for clinical trials in chronic lung disease. *Thorax.* 1987;42:773-8.
6. van der Molen T, Willemse BW, Schokker S, et al. Development, validity and responsiveness of the Clinical COPD Questionnaire. *Health Qual Life Outcomes.* 2003;1:13.
7. Jones PW, Harding G, Berry P, et al. Development and first validation of the COPD Assessment Test. *Eur Respir J.* 2009;34:648-654.
8. CAT Development Steering Group. COPD assessment test - healthcare professional user guide. <http://www.catestonline.org/images/UserGuides/CATHCPUser%20guideEn.pdf>. Accessed 31/1/2011.

9. Kocks JW, Tuinenga MG, Uil SM, et al. Health status measurement in COPD: the minimal clinically important difference of the clinical COPD questionnaire. *Respir Res.* 2006;7:62.
10. Schunemann HJ, Puhan M, Goldstein R, et al. Measurement properties and interpretability of the Chronic respiratory disease questionnaire (CRQ). *COPD.* 2005;2:81-9.
11. Singh SJ, Morgan MD, Scott S, et al. Development of a shuttle walking test of disability in patients with chronic airways obstruction. *Thorax.* 1992;47:1019-24.
12. Singh SJ, Jones PW, Evans R, et al. Minimum clinically important improvement for the incremental shuttle walking test. *Thorax.* 2008;63:775-777.
13. Revill SM, Morgan MD, Singh SJ, et al. The endurance shuttle walk: a new field test for the assessment of endurance capacity in chronic obstructive pulmonary disease. *Thorax.* 1999;54:213-22.
14. American Thoracic Society. ATS Statement: Guidelines for the Six-Minute Walk Test. *Am. J. Respir. Crit. Care Med.* 2002;166:111-117.
15. Casanova C, Celli BR, Barria P, et al. The 6 minute walk distance in healthy subjects: reference standards from seven countries. *Eur Respir J.* 2010.
16. Puhan MA, Chandra D, Mosenifar Z, et al. The minimal important difference of exercise tests in severe COPD. *Eur Respir J.* 2010.
17. Dodd JW, Jones PW. Limitations of calculating 'true' regression slope: impact on estimates of MID. *Eur Respir J.* 2011;IN PRESS.
18. Jones RC, Wang X, Harding S, et al. Educational impact of pulmonary rehabilitation: Lung Information Needs Questionnaire. *Respir Med.* 2008;102:1439-45.

19. Hyland ME, Jones RC, Hanney KE. The Lung Information Needs Questionnaire: Development, preliminary validation and findings. *Respir Med.* 2006;100:1807-16.

FIGURES

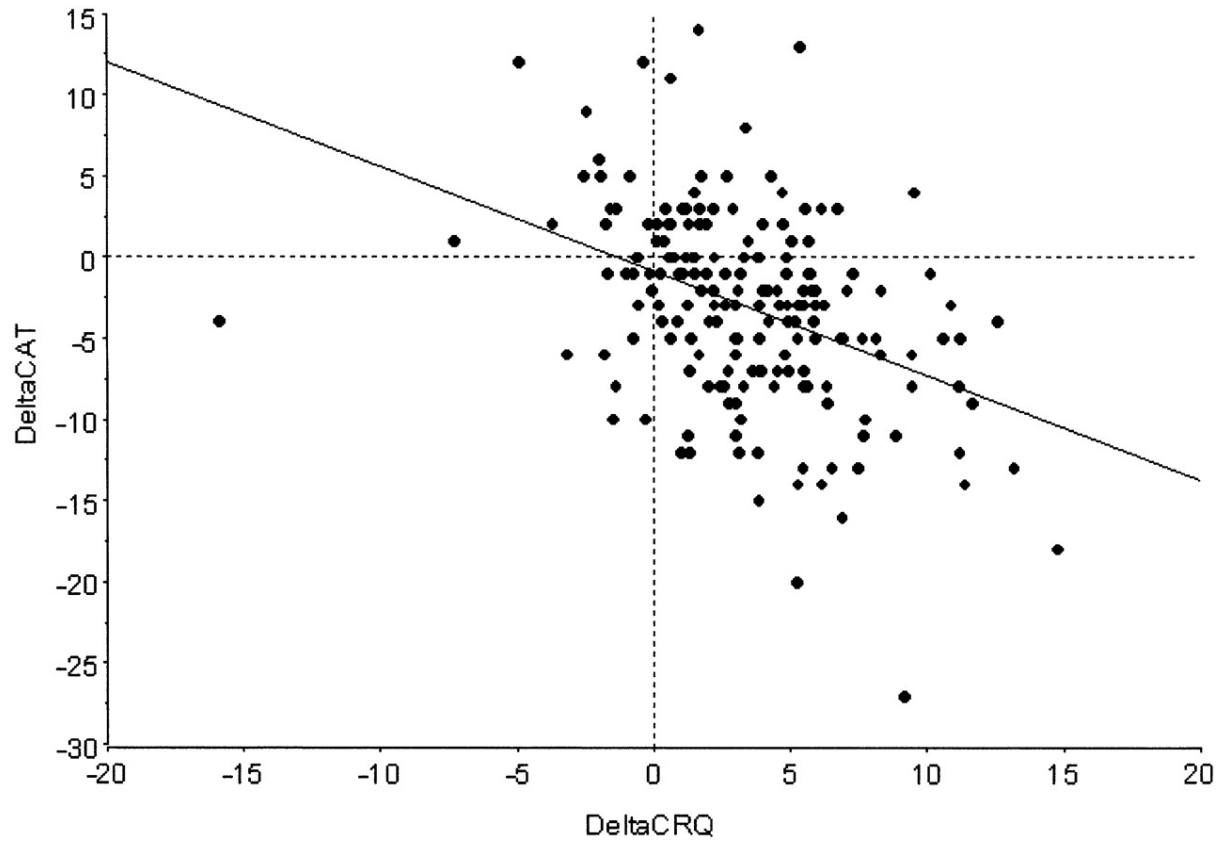


Figure 1 Change in CAT in response to pulmonary rehabilitation correlated with change in CRQ total score (R -0.41; $p < 0.001$).

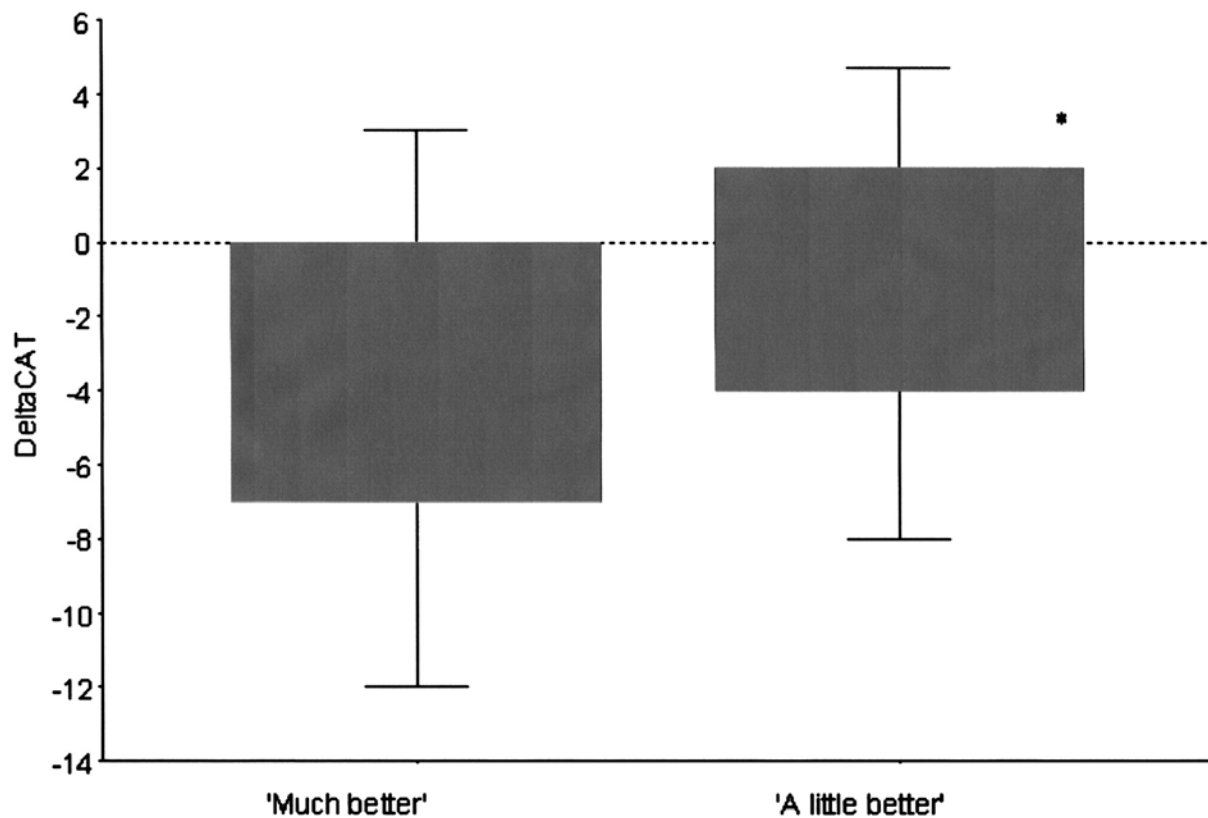


Figure 2 Change in CAT score after pulmonary rehabilitation corresponding to different responses to the anchor question “How do you feel your overall condition has changed after rehabilitation?” - “much better” n=162, $\Delta\text{CAT} -3.8\pm 6.1$; “a little better” n=88, $\Delta\text{CAT} -1.3\pm 4.5$ ($p < 0.002$). As only small numbers were available for these categories data for “no different” n=8 $\Delta\text{CAT} -2.3\pm 3.3$; and “a little worse” n=3 $\Delta\text{CAT} +2\pm 0$ are not shown.