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A field test of functional status as performance of activities of daily living in COPD patients

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Summary Patients with chronic obstructive pulmonary disease (COPD) frequently experience activity restrictions and discomfort during activities of daily living (ADL). Functional status refers to the capacity to perform ADL. Available tests only partly measure this domain. Our aim was therefore to establish an assessment tool for functional status in COPD, the Glittre ADL-test.

This field test includes a standardised set of ADL-like activities: Walking stairs, carrying, lifting objects, bending down and rising from a seated position. The primary variable was time to complete the test (ADL-time). Validity was investigated in 57 COPD patients by correlating ADL-time to pulmonary function, 6-min walking distance (6MWD) and questionnaires addressing health-related quality of life. Responsiveness was investigated in another 40 patients comparing ADL-time before and after rehabilitation.

Median ADL-time was 4.16 min (range 2.57–14.47). Spearman $\rho = 0.93$ for test–retest reliability. ADL-time correlated with forced expiratory volume in 1 s ($\rho = -0.61$), St. George's Respiratory Questionnaire activity subscore ($\rho = 0.43$), dyspnoea during ADL ($\rho = 0.35$) and hospitalisation rate ($\rho = 0.35$). Despite a close overall correlation with 6MWD ($\rho = -0.82$), variability was substantial, particularly for the more disabled patients. ADL-time improved significantly after rehabilitation.

Glittre ADL-test yields information complementary to 6MWD. It is a valid and reliable measure of functional status, useful for assessment of individual patients and rehabilitation programs.

Introduction

Chronic obstructive pulmonary disease (COPD) is characterised by airflow limitation and respiratory symptoms with subsequently deteriorating health

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status.[1] Health status is defined as the impact of health on a person's ability to perform and derive fulfilment from the activities of daily life,[2,3] and includes the two subcomponents health-related quality of life (HRQoL) and functional status. Functional status focuses on the capacity to perform activities of daily living (ADL) while HRQoL reflects how the patients feel that their daily life and well-being are affected by the disease.[4] A withdrawal from everyday tasks will often be accepted by the patients as unavoidable adjustments to a chronic disease. This lower level of performance in ADL may lead to a decline in related symptoms. Thus, we may record an apparent improvement in self-reported HRQoL while the patients' functional status is obviously worsened. It is therefore necessary to measure both components of health status.

One way to assess functional status is to ask the patient through a questionnaire. However, functional status as reported by the patient might be influenced by psychological factors or cognitive decline,[5] and the adoption of a sedentary lifestyle may lead to a self-reported functional performance lower than the actual capacity. Patients may also confirm that they are capable of completing a task, but the time expenditure is more difficult to estimate. The observation of patients during ADL would yield first hand information about functional status, but is time consuming.[6] A standardised test with activities that are representative of ADL could act as a compromise. Also, it will enable the observer to classify the patient's functional capacity according to the International Classification of Functioning, Disability and Health.[7] This form of evaluation has long traditions in other fields of medicine.[8] However, since it has been found that questionnaires addressing functional status developed for patients with movement restrictions are not always suitable for COPD patients without adjustments,[9] the same would be expected for field tests. For instance, the sit-to-stand test[10] leaves out upper extremity performance, which is known to cause alterations in ventilatory capacity and dyspnoea in COPD patients.[11–13] The same focus on the lower limbs is also present in the 6-min walking test. Therefore, a field test specifically aimed at the functional status in COPD patients would be preferable, but has not been published so far.

The aim of our study was to establish a measure for functional status in COPD as a standardised set of ADL-like activities: the Glittre ADL-test. The test was validated through comparisons with measures of the adjacent domains: lung function, exercise capacity and HRQoL. We also investigated reliability in a group of patients who performed the ADL-test on two consecutive days, and responsiveness as the change in test performance after pulmonary rehabilitation.

Materials and methods

Subjects

Patients with COPD[1] admitted to a 4-week inpatient pulmonary rehabilitation (PR) program (Table 1) were invited to participate in the study. To allow the study parameters to be measured soon after admission, only patients entering the program Mondays and Tuesdays were chosen. There is nothing in the admission procedures that could cause bias when selecting the patients in this manner. The Regional Medical Ethics Committee approved the study. Written informed consent was obtained from each patient. Patients were not included if they received long-term oxygen therapy. The physician in charge of the patient upon admission recorded all current co-morbidity, and the patient was not included if this co-morbidity was judged as a contributor to function limitation during ADL. Milder co-morbidity was categorised as internal, neuromuscular or psychiatric. The number of hospitalisations for exacerbations the past year was registered.

Prior to the main study, calculations of sample size were done based on a pilot study where COPD

Table 1 Multidisciplinary rehabilitation.

Type of intervention	Hours*
Group training, aerobics	11.0
Water gymnastics	6.0
Bicycle spinning	3.0
Outdoor walking with breathing exercises	6.0
Relaxation techniques	3.0
Mastery/living with chronic disease	7.0
Education (COPD, medication, nutr. ect)	12.5
Occupational therapy	2.5
Individual exercise training	1 h daily†

*Total time in full hours of group sessions offered during the 4 weeks of inpatient rehabilitation in addition to individual contacts with therapeutic team.

†Individual exercise program with moderate to high intensity endurance and resistance training on alternating days.

patients completed the ADL-test ($n = 22$), spirometry ($n = 22$) and SGRQ ($n = 14$). For the evaluation of validity and reliability of the ADL-test, 60 patients were included (Group A). Three persons declined to participate, leaving 57 patients in this group. To investigate the responsiveness to intervention, another 40 COPD patients were recruited (Group B).

Glittre ADL-test

The activities of the ADL-test (Fig. 1) were chosen to represent common activities essential in everyday life and known to be troublesome to COPD patients. Lareau and co-workers found that the 79 activities of the PFSDQ could be represented by 10.[14] Essential components were walking, lifting objects, and exposure to damp air. Carrying and bending also cause considerable discomfort for COPD patients,[15] for instance when they make beds, vacuum clean or bring groceries home. Rising from seated position depends on quadriceps muscular strength, which is known to be reduced in this group.[16] We chose the test tasks to resemble these daily activities while maintaining the simplicity of a standardised test. A backpack was selected for carrying load to allow both hands to be free to lift objects, and for support during walking. A weight of 2.5 kg approximates the weight of supplementary oxygen equipment, which can then be added if needed in the future without changing the test. We found that doubling the backpack load for men yielded about the same range of time to complete the test (ADL-time) in both genders. When developing the test, we increased the number of laps until the longest completion time was at least twice the shortest time spent by the patients tested, but not further than allowing the more disabled patients to complete all rounds. ADL-time was considered the main outcome variable, and was recorded in minutes (metric). Dyspnoea, measured with Borg CR10 scale,[17,18] and oxygen saturation (SpO_2), monitored by pulse oximetry (Nonin PalmSAT Model 2500), were recorded at start and finish. A physician or occupational therapist supervised the test, but gave no encouragement. In preliminary studies of healthy adult staff members we found 2 min to be the shortest time in which they could complete the test without violating the protocol.

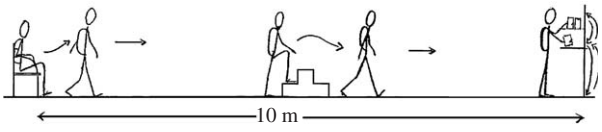

Figure 1 Glittre ADL-test. The test started with the patients rising from a seated position. Then, they walked 10 m, over the interposed two-step staircase, up to two shelves, that were adjusted in advance to shoulder and waist height of each patient. Three cartons weighing 1 kg positioned on the top shelf were moved one by one to the bottom shelf, down to the floor, back to the bottom shelf, and finally to the top shelf again. The patients then turned, walked back over the stairs to the chair, sat down, and immediately started the next lap by rising once more. The test consisted of five laps, and the patients were asked to complete them as quickly as possible. They were allowed to rest if necessary, but were told to resume activity as soon as they could. The patients carried a backpack containing 2.5 (women) or 5.0 (men) kg. Each step of the stair was 17 cm high and 27 cm deep.

All tests were undertaken between 10 am and 6 pm and at least 1 h after meals. All patients performed their first and second test at the same time of the day. To investigate reliability, patients in group A were tested on two consecutive days shortly after admission. The result from the first test was used for the examination of the correlation to other variables. Responsiveness was studied in Group B, where patients were tested once in the beginning, and once right before the end of the rehabilitation program.

Pulmonary function tests

Forced Vital Capacity (FVC) and Forced Expiratory Volume in 1 s (FEV_1) were recorded from the better of two forced flow-volume curves with mutual variability less than 5% (Masterlab, Jaeger, Würtzburg, Germany), which is the routine test procedure at Glittreklinikken. Residual Volume (RV) and Total Lung Capacity (TLC) were measured by whole body plethysmography, and diffusion capacity of the lung as transfer factor for carbon monoxide (TLCO) by single breath method and volume adjusted (KCO) (Masterlab, Jaeger, Würtzburg, Germany). Values were recorded as percentage of predicted values.[19,20] The height (m) and body weight (kg) of each patient were measured and the body mass index ($BMI = \text{bodyweight}/\text{height}^2$) calculated.

Questionnaires

HRQoL was measured by the St. George's Respiratory Questionnaire (SGRQ).[21] This questionnaire gives a total score ($SGRQ_{tot}$) and subscale scores for symptoms ($SGRQ_{sym}$), activity ($SGRQ_{act}$), and the impact of disease ($SGRQ_{imp}$).

Activity-related dyspnoea and functional performance were measured with Pulmonary Functional Status and Dyspnoea Questionnaire (PFSDQ).[13] Patients rate the dyspnoea experienced during 79

activities of daily living ($PFSDQ_{dys}$), and the *change* in activity level for the same activities from the time prior to developing a breathing problem to the present ($PFSDQ_{act}$). PFSDQ scores are presented as mean values. The PFSDQ also includes six questions addressing overall dyspnoea ($PFSDQ_{1-6}$). $PFSDQ_6$, formulated as ''Indicate how you feel with most day-to-day activities'', was considered of principal significance in the validation of the ADL-test since it reflects the general feeling of breathlessness during the ADL actually performed by the patient.

Exercise capacity

The 6-min walking test was undertaken according to ATS guidelines[22] on two consecutive days. SpO_2 and dyspnoea (Borg CR10) were measured at start and finish. The results from the test with the longest 6-min walking distance (6MWD) were used for further analysis.

Statistical analysis

Because of a skewed distribution of the ADL-time (Fig. 2), Spearman Rank Order Correlation (ρ) was used to estimate strength of the relationships between variables, and intra-individual change in ADL-time was assessed by Wilcoxon Signed Rank Test. Student's *t*-test or Mann Whitney *U* Test was employed for comparisons between group A and B as appropriate. The results from patients in group A were used to evaluate reliability and validity of the ADL-test. Responsiveness was investigated by comparing the change in ADL-time from the first to the second test in group A vs. group B. LogADL-time was entered as dependent variable in linear regression analysis. The software SPSS version 11.0 was used for all statistical analysis. The level of significance was set at $P<0.05$. Variables are presented as mean (SD) unless otherwise stated. Confidence interval (CI) limits are given as { }.

Results

The characteristics of the patients are summarised in Table 2. COPD was the function limiting disease, but 49% of the patients had mild co-morbidity. There were no significant differences between the patients in groups A and B. The ADL-test was administered in less than 20 min, including preparations. The patients understood the standardised instructions well. There were no adverse events. ADL-time ranged from 2.57 to 14.47 min with mean 4.67 and median 4.16 min (Group A). There was a predominance of individuals at the lower end of the range (Fig. 2).

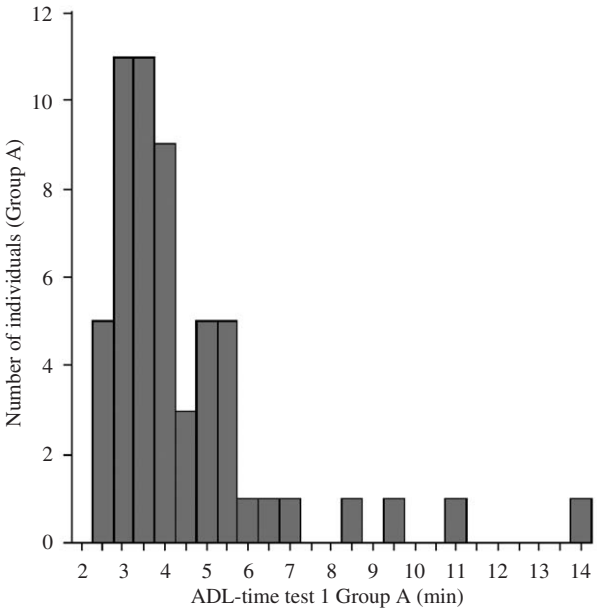

Figure 2 Distribution of time to complete the test (ADL-time). Number of patients from group A in each interval of 30 s.

Reliability (group A)

The 52 patients from group A who completed the second test put the same effort into both tests: Borg score for dyspnoea at the end of test 1 and 2 did not differ (6.2 (2.1) vs. 5.9 (2.1)), and the lowest value for SpO_2 was the same (88 (6)%). Spearman ρ between ADL-test 1 and 2 was 0.93 ($P<0.001$)(Fig. 3). There was a 0.37 min decline in ADL-time from test 1 to 2, 95% CI {−0.20 to −0.54}. This learning effect, when expressed as percentage of the first test, was the same (7%) throughout the range of results in ADL-time.

Responsiveness (group B)

The improvement in ADL-time after 4 weeks of rehabilitation was substantial: −0.89 min, 95% CI {−0.48 to −1.30}. This response after rehabilitation was significantly larger than the learning effect ($P = 0.01$).

Validity (group A)

The Spearman ρ for both ADL-time and 6MWD vs. other variables are listed in Table 3. In spite of a significant correlation between ADL-time and 6MWD, there was considerable variability in ADL-time for any given 6MWD (Fig. 4). Also, the patterns of correlation to other variables were different for

Table 2 Subject characteristics.

Characteristics	Group A	Group B
Gender, male/female, No.	31/26	22/18
Age (yr)	61 (8.0)	63 (7.7)
Body mass index (kg/m^2)	24 (4.5)	27 (4.4)
FVC (L)	2,8 (1.02)	2,6 (0.83)
FVC (% pred)	81 (19.7)	75 (16.4)
FEV_1 (L)	1,3 (0.54)	1,3 (0.43)
FEV_1 (% pred)	48 (15.4)	45 (11.4)
TLCO (% pred)	53 (19.0)	55 (18.2)
*K*CO (% pred)	60 (26.8)	67 (24.0)
TLC (% pred)	126 (18.8)	114 (23.5)
RV (% pred)	191 (53.2)	172 (56.3)
6-min walking distance (m)	477 (99.3)	439 (99.4)
$SGRQ_{tot}$	56 (15.6)	56 (15.0)
ADL-time*	4.16 [3.40, 5.47]	4.23 [3.57, 5.70]
Hospitalisations past year†	0 [0–7]	0 [0–7]

FVC: forced vital capacity; FEV_1: forced expiratory volume in 1 s; TLCO: transfer factor for carbon monoxide, single breath; *K*CO: transfer coefficient of the lunge; TLC: total lung capacity; RV: residual lung volume; $SGRQ_{tot}$: St. George's Respiratory Questionnaire, total score; % pred.: % of predicted values.

*Median [25th, 75th quartiles].

†Median [range].

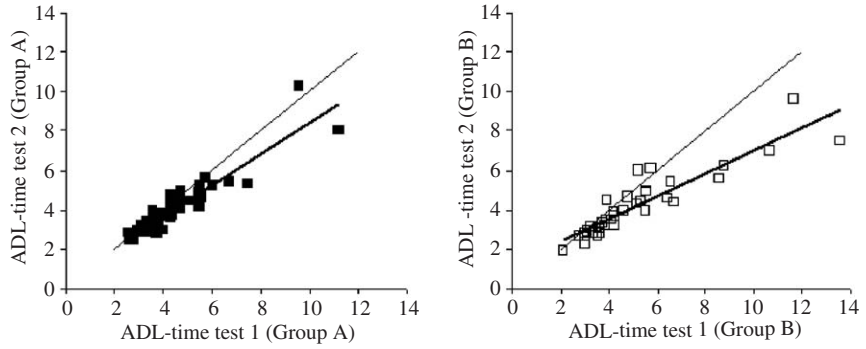

Figure 3 Test–retest reliability and responsiveness of the ADL-test. ADL-time in test 1 and 2 for patients in groups A (left) and B (right). Thick lines represent regression lines, thin lines identity lines.

ADL-time and 6MWD. The ADL-time was more closely related to airway obstruction, dyspnoea during daily activities ($PFSDQ_6$), BMI and hospitalisation rate than the 6MWD, whereas only the 6MWD correlated with the activity domain of the PFSDQ. Both a long ADL-time and a low 6MWD were associated with activity restriction ($SGRQ_{act}$). The hospitalisation rate during the past year was significantly higher among patients with a long ADL-time. Patients with an ADL-time above the median had a risk of three or more serious exacerbations five times the risk for those with shorter ADL-time.

In linear regression analysis, 6MWD, FEV_1% predicted and $PFSDQ_6$ were significant contributors to the variability in logADL-time (Beta −0.63, −0.26 and 0.20) with an adjusted R^2 of 0.73 for the combined model.

Discussion

Our results show that the Glittre ADL-test is an easily administered, valid and reliable measure of functional status. There was a significant relationship between ADL-time and disease stage, hospitalisation rate, exercise capacity, reported activity restrictions and dyspnoea during daily activities. Compared to 6MWD, the ADL-test gives additional information about functional status, in particular for the most disabled patients.

Table 3 Correlation coefficients.

Domain	Variable	Spearman ρ vs. ADL-time	Spearman ρ vs. 6MWD
HRQOL	$PFSDQ_{dys}$	0.30*	−0.47**
	$PFSDQ_{act}$	0.26	−0.42**
	$PFSDQ_{6}$	0.35**	−0.22
	$SGRQ_{tot}$	0.22	−0.41**
	$SGRQ_{act}$	0.43**	−0.56**
	$SGRQ_{sym}$	0.06	−0.15
	$SGRQ_{imp}$	0.12	−0.27
Lung function	FEV_1 (% pred.)	−0.61**	0.44**
	FVC (% pred.)	−0.44**	0.32*
	RV (% pred.)	0.42**	−0.37**
	TLC (% pred.)	0.30*	−0.42**
	TLCO (% pred.)	−0.65**	0.62**
Other	Neuromuscular comorbidity	0.27*	−0.30*
	Hospitalisations	0.35**	−0.28*
	BMI	−0.57**	0.47**
	Age	0.07	−0.26
	Gender	−0.05	0.27*
	6MWD	−0.82**	

HRQOL: health-related quality of life; PFSDQ: pulmonary functional status and dyspnoea questionnaire; $PFSDQ_{dys}$: PFSDQ, dyspnoea subscore; $PFSDQ_{act}$: PFSDQ, activity subscore; $PFSDQ_{6}$: PFSDQ, dyspnoea during most daily activities; SGRQ: St. George's Respiratory Questionnaire; $SGRQ_{tot}$: SGRQ, total score; $SGRQ_{act}$: SGRQ, activity subscore; $SGRQ_{sym}$: SGRQ, symptom subscore; $SGRQ_{imp}$: SGRQ, impact subscore; FVC: forced vital capacity; FEV_1: forced expiratory volume in one second; TLC: total lung capacity; RV: residual lung volume; TLCO: transfer factor for carbon monoxide, single breath; % pred: per cent predicted; BMI: body mass index; 6MWD: 6-min walking distance.
*Denotes a $P<0.05$.
** Denotes a $P<0.01$.

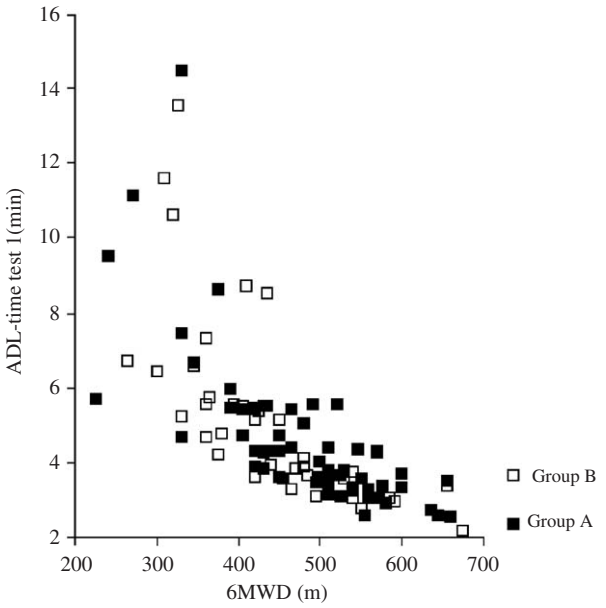

Figure 4 The 6-min walking distance (6MWD) vs. ADL-time for patients in group A and group B.

This study was performed among patients with COPD admitted to in-patient PR. They were probably more disabled from their disease than the average COPD patient, with an average SGRQ score higher in GOLD stadium II and III than reported by others.[23] In Norway, PR is available in few sites only, and the population is scattered. In-patient PR is therefore offered to patients who in other countries might have attended out-patient PR. Our material probably reflects the subgroup of COPD patients usually referred to PR, but not COPD patients in general.

The evaluation of content validity was a challenge, since no gold standard exists for functional status. The test components represent ADL described in the literature as troublesome for COPD patients.[12,13,24–27] Occupational therapists experienced in work with lung patients regarded the tasks as relevant to the concept we wanted to measure. A direct comparison with ADL functional status at home would be preferable, but difficult to conduct. Another possibility is the use of movement counters, but these estimate activity level, not ability to perform ADL.

A more strenuous test would probably add discriminatory strength among less affected individuals, but would increase the proportion of patients who stop before completion. Weights of 1 kg were chosen for the vertical movements

because ADL frequently involve repetitive handling of lighter objects, like groceries or dishes. With heavier weights, the ADL-test would have depended to a larger extent on muscular strength per se, and less on balance, coordination and work economy.

The close association between ADL-time and disease severity is consistent with our intention to measure disability caused by the COPD. We also found an elevated hospitalisation rate for patients with a long ADL-time. The risk of frequent exacerbations, an important negative prognostic factor,[28] was markedly higher among these individuals.

Patients with longer 6MWDs showed the closest correlation between 6MWD and ADL-time (Fig. 4). In these patients, ventilatory capacity and oxygen uptake dominate as exercise limiting factors and would be expected to restrain most activities to a similar degree. With progressing disease, other factors come to influence the ability to perform. Hyperinflation gives a lower inspiratory capacity, an increased work of ventilation and a dependency upon accessory respiratory muscles. Very high levels for oxygen consumption in proportion to maximal oxygen uptake have been found during practical tasks involving the upper extremities.[27] Patients with longstanding COPD will be at risk of a failing balance and coordination because of deconditioning and deteriorating muscular strength. These factors will differ between individuals and are likely causes for the large variability in ADL-time seen for patients with a low exercise capacity (Fig. 4). For these patients in particular, the ADL-test gives information about disability not measured by 6MWD, lung function or questionnaires alone.

ADL-time was related to the score of the questionnaire quantifying present limitations in activity ($SGRQ_{act}$). On the other hand, it was not correlated with the change in participation in ADL compared to the time prior to developing COPD ($PFSDQ_{act}$). One possible explanation is that the most disabled patients have had COPD for several years and find it difficult to remember the level of activity they once had for all the activities.

ADL-time correlated significantly with dyspnoea during most daily activities ($PFSDQ_6$), but not with general symptom intensity ($SGRQ_{sym}$). When asked directly prior to the ADL-test, the patients estimated that their dyspnoea for the test activities would be "weak" to "moderate" (mean Borg 2.6), while the dyspnoea they experienced upon test completion was "strong" (mean Borg 6.2). The test procedure, requiring the patient to work as fast as possible, is one reason for this discrepancy. Patients with COPD lower their pace for everyday activities,[25,26] but many still consider adequate self-pacing a daily challenge. An alternative test approach could be to instruct the patients to complete the ADL-test in their "usual" pace, and to observe work strategies, symptoms and oxygen saturation. However, changes in functional status would then be difficult to quantify. Incomplete recollection of symptoms may be another reason for the discrepancy between dyspnoea ratings. Retrospective ratings of exercise-induced dyspnoea correlate poorly with the dyspnoea actually experienced during exercise.[29] This emphasises the need for observational tests as a supplement to anamnestic information.

A change in ADL-time was expected when the test was repeated after 24 h. As seen in Fig. 3, reliability was still good. The 7% decrease is identical in amount to the increase seen in 6MWD for a second test performed after one day.[30] For the 6MWD, a small training effect (3%) is present also between the second and third test, but all such effects are believed to have worn off after a few weeks.[22,30] We expect the same to be the case for ADL-time, but further studies will be needed to know more about the learning effect for the ADL-test.

The ADL-test is responsive to intervention as the change in ADL-time was significantly greater than the learning effect. Our results are in agreement with Yohannes and co-workers,[9] who found an improvement in ADL functional status after rehabilitation even without any increase in the 6MWD. They concluded that upper extremity exercises during rehabilitation probably had a positive impact on functional status not assessable by the 6MWD. Arms are used extensively to perform ADL.

We conclude that Glittre ADL-test is a time-efficient, valid and reliable measure of functional status for COPD patients, and that it yields information about the capacity to perform ADL. The test will be of value in the assessment of individual patients and as outcome measurement for pulmonary rehabilitation programs.

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