The 5-Repetition Sit-to-Stand Test as an Outcome Measure for Pulmonary Rehabilitation in Subjects With Asthma

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BACKGROUND: The 5-repetition sit-to-stand test (5STS) is valid and responsive in subjects with COPD, but there is a lack of information in subjects with asthma. We aimed to evaluate the usefulness of the 5STS as an outcome measure of pulmonary rehabilitation in subjects with asthma as compared to subjects with COPD. METHODS: We conducted a retrospective evaluation of subjects with asthma or COPD who underwent pulmonary rehabilitation. Both before and after in-patient pulmonary rehabilitation, subjects underwent the 5STS and the 6-min walk test; dyspnea was assessed with the Medical Research Council scale and the Barthel Index for dyspnea, and the burden of symptoms was assessed with the COPD Assessment Test. RESULTS: Of 475 patients admitted during the study period, 103 subjects with asthma and 108 with COPD were included. After pulmonary rehabilitation, the 5STS improved significantly in both populations (by a median value of –1.7 s [interquartile range –4.2 to –0.5] and –1.1 s [interquartile range –3.4 to 0.0] in subjects with asthma and COPD, respectively; $P < .001$ for both, $P = .17$ between groups) independent of body mass index, as did other outcome measures. The baseline 5STS correlated slightly but significantly with age, the 6-min walk test, and the Barthel Index for dyspnea in both populations, whereas it correlated significantly with the Medical Research Council scale only in subjects with asthma and correlated with COPD Assessment Test only in subjects with COPD. No significant correlations between changes in the 5STS and in other assessed outcome measures before and after pulmonary rehabilitation were observed in subjects with asthma, whereas changes in the 5STS correlated slightly but significantly only with changes in 6-min walk test in subjects with COPD. CONCLUSIONS: The 5STS was a reliable outcome measure of pulmonary rehabilitation in subjects with asthma. It must be specifically assessed and may be included in the tools for assessment of effects of pulmonary rehabilitation also in these patients. *Key words: asthma; body mass index; COPD; exercise capacity; exercise training; pulmonary rehabilitation.* [Respir Care 2021;66(5):769–776. © 2021 Daedalus Enterprises]

Introduction

Asthma is a chronic respiratory disease that affects hundreds of millions of people globally. It is a heterogeneous disease characterized by chronic airway inflammation with a history of respiratory symptoms such as wheezing, shortness of breath, chest tightness, and cough that varies over time and in intensity, together with variable expiratory air flow limitation.[1] Patients with asthma may avoid or limit their physical activity because of fear of symptoms that may worsen during or after exercise.[2]

Pulmonary rehabilitation has strong evidence of effectiveness in reducing dyspnea and improving exercise

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capacity and health-related quality of life (HRQOL) in subjects with COPD.[3] Therefore, current guidelines for COPD recommend pulmonary rehabilitation programs, including the key component of exercise training, in the comprehensive management of disease.[4] In patients with asthma, pulmonary rehabilitation has been demonstrated to improve exercise capacity, disease control (ie, use of rescue medication or number of emergency service admissions), and HRQOL, and to reduce dyspnea, anxiety, and depression.[5,6]

Outcomes of pulmonary rehabilitation are usually evaluated on the basis of exercise capacity by means of the cardiopulmonary exercise test or so-called field tests, such as the 6-min walk test (6MWT).[7] Moving from sitting to standing is a common activity of daily living. The 5-repetition sit-to-stand test (5STS) is a test of lower limb function, assessing the fastest time required to stand 5 times from a chair with arms folded. The test has been validated in healthy community-dwelling adults and is reliable, valid, and responsive in subjects with COPD, with an estimated minimal clinical important difference of 1.7 s.[8] The 5STS is considered a practical and functional outcome measure suitable for use in most health care settings. To our knowledge, there is a lack of validation studies in subjects with asthma. We hypothesized that the 5STS would be as useful in patients with asthma as in those with COPD as an outcome measure of pulmonary rehabilitation. Therefore, the aim of this study was to assess the 5STS as an outcome measure of pulmonary rehabilitation in subjects with asthma as compared to subjects with COPD.

QUICK LOOK

Current knowledge

Prescription of pulmonary rehabilitation is commonly based on evaluation of exercise capacity by means of the cardiopulmonary exercise test or field tests. The 5-repetition sit-to-stand test (5STS) is a test of lower limb function used to assess the fastest time spent to stand 5 times from a chair. The test has been validated in healthy community-dwelling adults and is reliable, valid, and responsive in patients with chronic respiratory diseases, with an estimated minimal clinical important difference of 1.7 s. It is considered a practical functional outcome measure suitable for use in most health care settings.

What this paper contributes to our knowledge

The 5STS improved significantly after pulmonary rehabilitation in subjects with asthma as well as in subjects with COPD. The changes in 5STS after pulmonary rehabilitation did not correlate with changes in any other outcome measure, such as dyspnea, functional limitation, and symptom burden. Therefore, the 5STS cannot be used as a surrogate for other outcome measures.

Methods

This retrospective study included subjects with asthma or COPD admitted consecutively for an in-patient pulmonary rehabilitation program from January to December 2019 at Istituti Clinici Scientifici (ICS) Maugeri of Tradate, Italy, a reference institution for pulmonary rehabilitation. All medical records of subjects meeting the inclusion criteria were retrospectively analyzed to complement available records in the Hospital Informatics System. The Ethics Committee of ICS Maugeri approved the study protocol (#1078). Subjects gave their informed consent to the scientific use of their data.

The inclusion criteria were patients age $\geq$ 18 y, diagnosis of asthma according to the current Global Initiative for Asthma (GINA) guidelines,[1] diagnosis and severity of COPD as confirmed with spirometry according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines,[4] and indications for pulmonary rehabilitation on the basis of reported limitations of activities of daily life or worsening of dyspnea during exercise.[9-11] At admission, all subjects were in stable condition for at least 30 d as assessed by the absence of worsening of symptoms (ie, no change in dyspnea, cough, or sputum beyond day-to-day variability that would have been sufficient to warrant a change in their regular management). All subjects received their regular treatment for their disease stage according to current guidelines.[1,4] Exclusion criteria from pulmonary rehabilitation were oncological, neurological, ischemic cardiovascular diseases; heart failure; or inability or refusal to perform evaluations or pulmonary rehabilitation.

A multidisciplinary team of chest physicians, nurses, physical therapists, dieticians, and psychologists offered care. The standard in-patient multidisciplinary program was the same for both populations and included the optimization of drug therapy, specific education plans for each disease, nutritional programs, psychosocial counseling when appropriate, and at least twelve 30-min daily sessions over a period of 3 weeks; sessions consisted of supervised exercise training according to Maltais[12] until the subject could perform 30 min of continuous cycling at 50–70% of the maximum load calculated on the basis of the baseline 6MWT according to Luxton et al.[13] The work load was increased by 5 watts when subjects scored their dyspnea or leg fatigue as $<$ 3 on a modified 10-point Borg scale.[14] The work load was unchanged if the Borg score was 4 or 5 and

Table 1. Details of the 5-Repetition Sit-to-Stand Test

Number of tests and duration	2 repetitions (the first as learning test), < 5 min.
Equipment	Stopwatch, chair (straight-backed, armless with hard seat, stabilized by placing it against a wall; floor-to-seat height 46 cm). Using the same chair is recommended for ongoing assessment.
Test run	Sit with the back resting against the seatback and feet flat on the floor, arms folded across the chest. Stand up all the way and sit down once.*
Instruction	Stand up all the way and sit down until the back rests against the seatback without use of the upper limbs; repeat 5 times, as fast as possible, starting when I say, "Go."
Timing	With a stopwatch, start on the command "Go" and stop at the end of the fifth completed stand.
Scoring	Register the amount of time in seconds (to the nearest decimal) it takes the patient to complete the test.
Additional recommendations	Deviations from standardized protocol would be appropriate if the patient is very short (eg, their feet do not touch the floor) or is very tall; document such deviations and reasons. If the patient does not complete 5 repetitions or is unable to complete the test without assistance, it is also recommended to document the reasons.

* If the subject is unable to complete the test run, the 5-repetition sit-to-stand test is terminated.

was reduced for scores > 5. Resistance training for the upper limbs (mainly biceps and triceps) and lower limbs (mainly quadriceps and glutes) with weights was also performed (5 times/week for 20–30 min).

The following data were reported from subjects' discharge data records: diagnosis; demographics (eg, age, gender); anthropometrics (ie, body mass index [BMI])[15]; reported number and diagnosis of comorbidities according to the Cumulative Illness Rating Scale, including the Comorbidity Index and the Severity Index[16]; lung function assessed according to the American Thoracic Society guidelines[17] by means of a body plethysmograph using predicted values according to Quanjer.[18]

Several evaluations were performed and recorded before pulmonary rehabilitation (ie, T0) and after pulmonary rehabilitation (ie, T1). The 6MWT was conducted according to accepted standards[7] using the predicted values of Enright and Sherrill.[19] The best of 2 consecutive performances (2 h apart) conducted with pulse oximetry monitoring in a corridor 30 m long and 3 m wide under quiet conditions and without distractive stimuli was recorded for analysis. At the beginning and at the end of walking, subjective sensations of both dyspnea and leg fatigue were assessed with a modified Borg scale but were not reported in the database.[14] In the 5STS test, seated subjects were asked to come forward on the chair seat until the feet were flat on the floor and to fold their arms across the chest. Subjects were instructed to stand up all the way and sit down landing firmly, as quickly as possible, 5 times without using the arms. After a learning performance, the time spent in a second performance was recorded.[20] Details are described in Table 1. Dyspnea was evaluated with the Medical Research Council scale[21] and the Barthel Index for dyspnea.[22] The symptom burden was assessed with the COPD Assessment Test.[23,24] Data are presented as mean ± SD or median (interquartile range [IQR]) when variables were not normally distributed.

The sample size was calculated based on the effect size of the study in subjects with COPD.[8] A total number of 90 patients was required to detect variations in terms of 5STS outcomes corresponding to Cohen's d = 0.32,[8] with a statistical power of 0.85 assuming a significance level of $P = .05$ (2-sided t test for paired samples). Statistical power calculations were performed with G*Power software 3.1.9.2.

The primary outcome measure was the change in the 5STS measurements after pulmonary rehabilitation. Secondary outcomes were the correlations of such changes with changes in the other assessed outcome measures and correlations of baseline 5STS measurements with other baseline outcome measures. The Student t test and the Mann-Whitney test were used to compare the populations for quantitative variables following their parametric and non-parametric distribution, respectively. The Student t test or the Wilcoxon test for paired samples were used to evaluate data before and after pulmonary rehabilitation. The chi-square test was used for categorical variables. The Spearman test was used to check the data correlation. $P < .05$ was considered as significant. SPSS 20 was used for all these statistical computations (IBM, Armonk, New York).

Results

Of 475 patients admitted during the study period, 103 subjects with asthma and 108 subjects with COPD fulfilled the inclusion criteria. The study flow chart is shown in Figure 1. Demographic, anthropometric, physiological, and clinical characteristics of the subjects are shown in Table 2. Subjects with asthma were slightly younger and more likely to be female, to have a higher BMI (31.1% of them had a BMI > 30 kg/m^2), and to have more severe dyspnea as assessed with the Medical Research Council scale. This group also exhibited slightly better 6MWT values expressed as percentage of predicted values. No differences

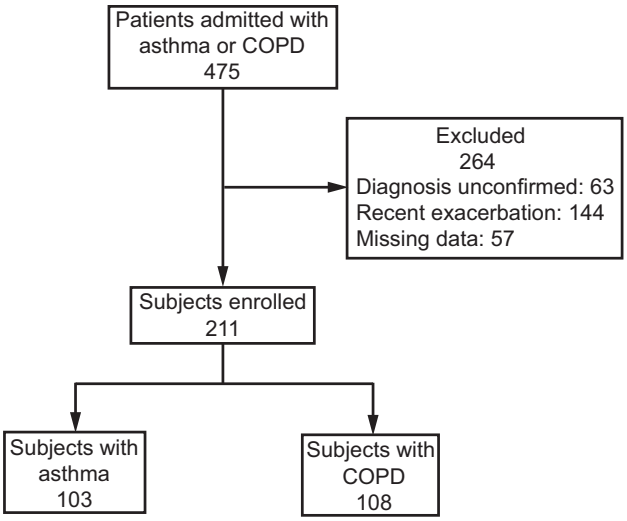

Figure 1. Flow chart.

in 5STS were found when stratified according to disease severity.

As shown in Table 3, after pulmonary rehabilitation the 5STS and other assessed outcome measures significantly improved in both populations. No changes in outcomes after pulmonary rehabilitation were significantly different between the 2 populations.

There was no significant difference in age between subjects with asthma and BMI < 30 kg/m^2 and those with asthma and BMI > 30 kg/m^2 (70.9 $\pm$ 9.3 y vs 69.8 $\pm$ 8.2 y, $P = .66$). The difference between baseline 5STS measures ($P = .43$) and 5STS measures after pulmonary rehabilitation ($P = .28$) were not significantly different across subjects with asthma according to BMI: from 15.9 s (IQR 12.7–17.1) to 12.6 s (IQR 11.2–14.4), $P = .43$; and from 15.5 s (IQR 12.7–17.3) to 13.3 s (IQR 11.6–15.1), $P = .28$, in subjects with BMI < 30 kg/m^2 and in those with BMI > 30 kg/m^2, respectively. As shown in Table 4, the changes in all other assessed outcome measures after pulmonary rehabilitation were not significantly different between the 2 populations of subjects with asthma as well. There were also no significant differences in any outcome measure between baseline and after pulmonary rehabilitation in subjects with COPD according to BMI.

Table 5 shows that the baseline 5STS correlated slightly but significantly with age, baseline 6MWT distance, and Barthel Index for dyspnea in both populations, whereas it correlated significantly with the Medical Research Council scale only in subjects with asthma and with the COPD Assessment Test only in subjects with COPD. As shown in Table 6, no significant correlation between changes in 5STS and in other assessed outcome measures was observed in subjects with asthma, whereas the changes in 5STS correlated slightly but significantly only with changes in 6MWT in subjects with COPD.

Discussion

Based on a search of the literature, to our knowledge this study is the first to show that outcomes of the 5STS significantly improve after pulmonary rehabilitation in subjects with asthma. The improvement in 5STS outcomes after pulmonary rehabilitation does not correlate with changes in any other outcome measure of pulmonary rehabilitation; therefore this test cannot be used as a surrogate for other pulmonary rehabilitation outcome measures and cannot be predicted by other outcome measures.

Moving from a sitting to a standing position is performed daily by active people, and significant functional limitations can occur when the ability to rise from a seat is impaired. The 5STS test indirectly assesses exercise tolerance, lower limb muscle function, and balance. The 5STS has been shown in subjects with COPD to correlate well with other objective physical performance measures such as 6MWT, HRQOL, and dyspnea as well as prognostic indices.[25-28] A recent study by Sánchez-Martínez et al[29] involving subjects with COPD reported that poor performance on the 5STS is one of the most relevant independent predictors of transitions to new states of low physical activity.

It is hard to categorize the 5STS as a strength test rather than an endurance test. Jones et al[8] reported that outcomes of the 5STS correlated significantly with measures of exer cise capacity, lower limb strength, HRQOL, and dyspnea. Furthermore, performance of sit-to-stand tests is associated significantly with a range of sensorimotor, balance, and psychological factors in older, community-dwelling people.[30]

It could be hypothesized that the 5STS is a valid surrogate for the 6MWT, especially when space and time are limited. Ozalevli et al[25] reported a correlation of the 1-min sit-to-stand test with 6MWT ($r = 0.75$, $P < .001$), stronger than the correlation between 5STS and 6MWT noted in our study. There is insufficient scientific background at this time to explain the reason why the 1-min sit-to-stand has a better correlation with the 6MWT than the 5STS. On the basis of our results we can only hypothesize that the shorter duration of the 5STS makes it less sensitive than the 1-min test.

In addition, as an original result, our results indicate that changes in 5STS after pulmonary rehabilitation did not correlate with the changes in 6MWT. The 2 tests are therefore not interchangeable as outcome measures for pulmonary rehabilitation. The 5STS test did not correlate with any index of symptom burden like the COPD Assessment Test, which is an outcome measure commonly used in both populations we studied.[24] These results indicate that the measures evaluate different effects of pulmonary rehabilitation. Therefore, the test cannot be used as a surrogate for other outcome measures in the pulmonary rehabilitation setting, and the 5STS cannot be predicted by other outcome measures.

Table 2. Subject Characteristics

	All Subjects	Subjects With Asthma	Subjects With COPD	*P*
Subjects	211 (100)	103 (48.8)	108 (51.1)	
Male	115 (54.5)	41 (39.8)	74 (68.5)	< .001
Age, y	71.7 ± 8.3	70.3 ± 8.6	72.9 ± 7.8	.01
Body mass index, kg/m^2	30.3 ± 6.7	32.5 ± 6.8	28.2 ± 6.0	< .001
FEV_1, % predicted	65.7 ± 24.3	64.8 ± 24.5	66.6 ± 24.2	.62
FVC, % predicted	82.5 ± 20.1	80.5 ± 19.8	84.4 ± 20.3	.17
FEV_1/FVC, %	62.0 ± 15.1	62.1 ± 15.5	61.9 ± 14.8	.18
CIRS: Severity Index	1.8 (1.5–1.9)	1.8 (1.6–1.9)	1.7 (1.5–1.8)	.08
CIRS: Comorbidity Index	4.0 (3.0–5.0)	4.0 (3.0–5.0)	4.0 (3.0–5.0)	.058
GINA steps				NA
1	NA	3 (2.9)	NA	
2	NA	4 (3.9)	NA	
3	NA	21 (20.4)	NA	
4	NA	41 (39.8)	NA	
5	NA	34 (33.0)	NA	
GOLD stage				NA
1	NA	NA	35 (32.4)	
2	NA	NA	45 (41.7)	
3	NA	NA	22 (20.4)	
4	NA	NA	6 (5.5)	
GOLD risk				NA
A	NA	NA	29 (26.8)	
B	NA	NA	41 (38.0)	
C	NA	NA	16 (14.8)	
D	NA	NA	22 (20.4)	
5-repetition sit-to-stand test, s	14.8 (12.5–16.7)	15.7 (12.7–17.3)	14.6 (12.1–16.6)	.17
MRC scale	2.0 (1.0–3.0)	2.2 (1.0–3.0)	2.0 (1.0–2.0)	.044
Barthel Index-dyspnea	14.0 (7.5–21.5)	14.0 (7.5–21.5)	13.0 (6.2–21.7)	.92
COPD Assessment Test	12.0 (7.0–17.0)	12.0 (7.5–16.5)	12.0 (7.0–18.0)	.90
6MWD				
Distance, m	397.9 ± 106.4	410.8 ± 96.5	385.5 ± 114.2	.08
Distance, % predicted	94.0 (81.0–110.0)	98.0 (86.0–113.0)	90.5 (73.2–106.7)	.002

Data are presented as *n* (%), mean ± SD, or median (interquartile range).
CIRS = Cumulative Illness Rating Scale
GINA = Global Initiative for Asthma
GOLD = Global Strategy for Chronic Obstructive Lung Disease
NA = not applicable
MRC = Medical Research Council
6MWD = 6-min walk distance

Patients with both obesity and asthma have more symptoms, greater difficulty in controlling disease, more frequent and severe exacerbations, decreased response to both reliever and control medications, and worse HRQOL than patients without obesity, and improvement in uncontrolled symptoms and in HRQOL are reported after weight loss as well as with medical therapy.[31,32] In the last 20 years, the link between asthma and obesity has been highlighted, and this connection can strongly influence the clinical management of respiratory symptoms. An increased prevalence of asthma[33] has been reported in both subjects who are underweight and those who are obese,[34] and most studies in adults with asthma show an increased prevalence of subjects with obesity compared to normal population, suggesting that obesity could increase the risk of asthma.[35]

The mean BMI of our subjects with asthma was > 30 kg/m^2; in 31.1% of our subjects, BMI was > 30 kg/m^2. Baseline 5STS outcomes were not significantly different between the subjects with BMI above or below 30 kg/m^2, and we noted similar improvements in all of the assessed outcome measures in these 2 groups. Our results are in line with a previous randomized trial in subjects with obesity (BMI ≥ 30 kg/m^2) and asthma with suboptimal control of respiratory symptoms.[36]

In our study, the same exercise training protocol was used for subjects with asthma and those with COPD. Both

Table 3. Significant Differences in Outcome Measures Before and After Pulmonary Rehabilitation

	Asthma		*P*	COPD		*P*	*P* (Asthma vs COPD)
	T0	T1		T0	T1		
5STS, s	15.7 (12.7–17.3)	13.9 (11.3–15.1)	< .001	14.6 (12.1–16.6)	13.1 (11.0–15.6)	< .001	
Δ5STS	–1.7 (–4.2 to –0.5)			–1.1 (–3.4 to –0.0)			.17
MRC scale	2.2 (1.0–3.0)	1.2 (1.0–1.3)	< .001	2.0 (1.0–2.0)	1.0 (1.0–1.0)	< .001	
ΔMRC scale	–1.0 (–1.0 to –1.0)			–1.0 (–1.0 to –0.0)			.32
Barthel Index for dyspnea	14.0 (7.5–21.5)	5.0 (0.0–10.0)	< .001	13.0 (6.3–21.8)	4.0 (0–10.5)	< .001	
ΔBarthel Index for dyspnea	–8.0 (–11.5 to –5.0)			–8.0 (–12.0 to –5.8)			.08
COPD Assessment Test	12.0 (7.5–16.5)	5.0 (2.0–10.0)	< .001	12.0 (7.0–18.0)	5.0 (3.0–10.0)	< .001	
ΔCOPD Assessment Test	–6.0 (–10.0 to –2.0)			–5.0 (–9.0 to –2.0)			.69
6MWD, m	410.8 ± 96.5	443.2 ± 97.0	< .001	385.5 ± 114.2	414.1 ± 106.4	< .001	
Δ6MWD, m	31.2 ± 48.5			31.2 ± 53.5			.056
6MWD, %	98.0 (86.0–113.0)	107.0 (96.0–118.0)	< .001	90.5 (73.2–106.7)	96.5 (76.5–112.7)	< .001	
Δ6MWD, %	5.0 (1.0–10.0)			6.0 (–1.7 to 14.0)			.69

Data are presented as mean ± SD or median (interquartile range).
5STS = 5-repetition sit-to-stand test
MRC = Medical Research Council
6MWD = 6-min walk distance

Table 4. Differences in Outcome Measures in Subjects With Asthma After Pulmonary Rehabilitation

	Body Mass Index		*P*
	< 30 kg/m^2	≥ 30 kg/m^2	
Δ5STS, s	–1.02 (–3.7 to 0.0)	–1.75 (–4.5 to –0.7)	.21
ΔMRC scale	–1.00 (–1.0 to –1.0)	–1.00 (–1.0 to –1.0)	.74
ΔBarthel Index for dyspnea	–8.00 (–1.0 to –5.0)	–8.00 (–13.0 to –5.3)	.19
ΔCOPD Assessment Test	–6.00 (–10 to –2.8)	–6.00 (–9.0 to –2.0)	.48
Δ6MWD, m	34.60 ± 56.50	28.90 ± 42.70	.16

Data are presented as mean ± SD or median (interquartile range).
5STS = 5-repetition sit-to-stand test
MRC = Medical Research Council
6MWD = 6-min walk distance

Table 5. Significant Correlations Between Baseline 5STS and Other Outcome Measures

	Asthma		COPD	
	Rho	*P*	Rho	*P*
Age, y	0.389	< .001	0.365	< .001
MRC scale	0.284	.01	0.114	.27
Barthel Index for dyspnea	0.389	< .001	0.224	.02
COPD Assessment Test	0.189	.09	0.322	.001
6MWD	0.495	< .001	0.489	< .001

MRC = Medical Research Council
6MWD = 6-min walk distance

Table 6. Correlations Between Changes in 5STS and Other Outcome Measures Before and After Pulmonary Rehabilitation

	Asthma		COPD	
	Rho	*P*	Rho	*P*
ΔMRC scale	0.087	.47	–0.140	.19
ΔBarthel Index for dyspnea	0.069	.57	0.011	.91
ΔCOPD Assessment Test	0.179	.14	–0.096	.40
Δ6MWD	–0.179	.11	–0.260	.01

MRC = Medical Research Council
6MWD = 6-min walk distance

GOLD[4] and GINA guidelines[1] recommend physical activity and pulmonary rehabilitation without any specific indication of programs or schedules. Several studies have reported the usefulness of exercise training programs used for patients with COPD in treating patients with asthma and other diseases, and in our study both populations saw benefits.[2,6,37,38]

This study has several limitations. It is a retrospective analysis with a COPD population serving as the control group. It would be interesting to have a control group of subjects who were not involved in any rehabilitation program. However, our sample size provided sufficient power to answer the research question, covering a wide range of severity; and failing to perform pulmonary rehabilitation in these subjects would have been unethical given the unquestionable effectiveness of pulmonary rehabilitation in these subjects. In addition, we did not perform any test of peripheral muscle function to compare with the 5STS outcomes.

Conclusions

Outcomes of the 5STS improved significantly after pulmonary rehabilitation in subjects with asthma as well as in subjects with COPD. The changes in 5STS outcomes after pulmonary rehabilitation did not correlate with changes in any other assessed outcome (ie, the Medical Research Council scale, the Barthel Index for dyspnea, the COPD Assessment Test, or the 6MWT). Therefore, the 5STS test cannot be used as a surrogate for other outcome measures in the pulmonary rehabilitation setting, nor can 5STS outcomes be predicted by other outcome measures. The 5STS must be assessed specifically, and it may be included as a tool for the assessment of effects of pulmonary rehabilitation on functional limitations in subjects with asthma.

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