Dyspnea during Speech in Chronic Obstructive Pulmonary Disease Patients: Effects of Pulmonary Rehabilitation

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Key Words

Chronic obstructive pulmonary disease • Dyspnea • Lung volumes • Phonatory tasks • Pulmonary rehabilitation

Abstract

Background: For patients with limited physical activities who use oral communication for most social activities, the assessment of dyspnea during speech activities (DS) may provide relevant measurement criteria. Although speech production is altered by lung disease it has not been included in current dyspnea assessment tools. **Objectives:** We evaluated DS in patients with chronic obstructive pulmonary disease (COPD) with the aim of assessing: (i) the responsiveness to treatment of this newly developed evaluative dyspnea tool and (ii) whether DS is an independent measurement of other traditional outcomes. **Methods:** We assessed lung function, the 6-min walking test (6'WT), chronic exertional dyspnea (MRC and BDI/TDI), and DS using the speech section of the University of Cincinnati Dyspnea Questionnaire (UCDQ) before and after a pulmonary rehabilitation program in 31 patients with COPD. **Results:** The following items of the speech section of the UCDQ caused dyspnea: conversation, raising the voice, phoning, speaking to

a group, talking in a noisy place, and singing. The mean overall DS score was $60 \pm 23\%$ of a maximal potential DS score. Pulmonary rehabilitation reduced each item of DS independently of change in lung function, chronic exertional dyspnea, and 6'WT. **Conclusions:** We concluded that DS is responsive to a respiratory rehabilitation program in patients with COPD. Evidence of independent objective measures supports the validity of a routine multivariable assessment including DS. We recommend assessment of DS particularly for patients who rely extensively on speech for communication.

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Introduction

Dyspnea is commonly evaluated by questioning chronic obstructive pulmonary disease (COPD) patients about their ability to exercise. However, for patients with limited physical activities who use oral communication for most social activities, assessment of dyspnea during speech activity (DS) may provide relevant measurement criteria. Although speech production is altered by lung disease it has not been included in current dyspnea as-

assessment tools. To overcome this drawback a questionnaire about dyspnea during speech and physical activities has recently been proposed by researchers at the University of Cincinnati [1]. The University of Cincinnati Dyspnea Questionnaire (UCDQ) was developed to measure the impact of dyspnea during physical activity, speech activity, and simultaneous speech and physical activity. The factors extracted from each section are related to the severity of dyspnea [1].

The development of a DS tool has yet to be defined in patients with COPD. The predictive capability of some particular regression equations is notably weak and clinically meaningless [1]. If we accept the concept that patients who use speech as an essential way of controlling their environment may need the services of a special language pathologist, then it is important to provide valid and reliable information on DS, particularly in patients who rely primarily on speech for communication.

Phonetic tasks impose considerable respiratory demands both in terms of expiratory flow and expiratory excursions in lung volume [2]. End expiratory lung volume (EELV) decreases below functional residual capacity (FRC), reduces expiratory reserve volume (ERV), and essentially impinges on the maximal expiratory flow-volume curve [2]. In the presence of a markedly reduced expiratory flow reserve, as is the case in severe COPD [3, 4], a reduced ERV is expected to increase tidal expiratory flow limitation [5], potentially impacting DS.

Based on previous studies suggesting the utility of pulmonary rehabilitation programs (PRP) in modulating the mechanical constraints of breathlessness [6–8] we hypothesized that DS is responsive to PRP in patients with COPD.

Therefore, the aim of this study was to assess the responsiveness of this newly developed evaluative dyspnea tool. We also wished to investigate whether DS provides independent information that complements physiological data.

Patients and Methods

Patients

We studied 31 patients with stable mild-to-very severe COPD before and after enrolment into a 24-session PRP. None had abnormalities of the spinal column or speech or hearing defects. They entered the PRP after satisfying the following criteria: (i) a long history of smoking (mean 40 pack-years) and a Medical Research Council (MRC) dyspnea score >2 ('walks slower than people of the same age on the level because of breathlessness or has to stop for breath when walking at own pace on the level') [9]; (ii) clinically stable condition with no exacerbation or hospital ad-

mission in the preceding 4 weeks, and (iii) free from other significant disease potentially contributing to dyspnea. Patients did not respond significantly to the administration of a therapeutic dose of a short-acting β_2 -agonist before entering the PRP. During the PRP patients were treated with long-acting β_2 -agonists in association with ICS and anticholinergic bronchodilators. Fifteen COPD patients, matched for severity of obstruction, served as the control; DS was evaluated in them twice within a 4-week interval.

The study was approved by the local ethics committee and subjects gave their informed consent.

Functional Evaluation

Routine spirometry, obtained with subjects seated in a comfortable armchair, was measured according to ATS/ERS guidelines [10]. Lung volumes were measured using a volume displacement body plethysmograph (6200 Autobox DL; SensorMedics, Yorba Linda, Calif., USA). The normal values for lung volumes were from the European Coal and Steel Community [11].

Arterial blood gases were measured using an IL-1650 blood gas analyzer (Instrumentation Laboratory, Milan, Italy).

Pulmonary Rehabilitation Program

The PRP protocol included education, breathing techniques, and exercise sessions with endurance training for the upper and lower limbs [7, 8, 12]. Breathing retraining did not include any speech therapy or any encouragement to control speech-induced dyspnea. The educational topics included medication and oxygen use, nutrition, panic control, and relaxation techniques, as well as psychosocial support and end-of-life issues. The exercise program included a supervised cycle (60%WL of peak value until exhaustion), supported arm ergometry, and 30 min of leisure walking. The PRP lasted 4 weeks and was conducted 6 days a week, once daily the first week and twice daily thereafter.

Six-Minute Walking Test

The 6-min walking test (6'WT) was carried out according to American Thoracic Society guidelines [13]. All patients underwent 2 tests before and after the PRP and the best result was taken as representative.

Exertional Dyspnea

Chronic exertional dyspnea was assessed using the 5-point MRC scale [9], the baseline dyspnea index (BDI), and the transitional dyspnea index (TDI) by Mahler et al. [14]. The modified MRC scale is a 5-point rating scale that relates primarily to the magnitude of the physical activities that provoke dyspnea. The BDI is a multidimensional instrument for measuring dyspnea based on 3 components that evoke dyspnea: magnitude of the task, magnitude of the effort, and functional impairment. A baseline focal score obtained as the sum of the 3 components ranges from 0 to 12, i.e. the lower the rating the worst the dyspnea. The TDI, an evaluative instrument, describes specific criteria for each of the 3 components to measure changes from the baseline state. The TDI focal score provides ratings for changes in dyspnea (range -9 to $+9$) compared to the baseline state based on 7 grades [-3 (major deterioration) to $+3$ (major improvement)].

Speech Dyspnea

In this study we analyzed 10 speech items from the questionnaire proposed by Lee et al. [1] (table 1). The creation of the ques-

Table 1. Breathlessness during speech: dyspnea questions

Items		Not at all SOB		Occasionally SOB		Always SOB	Not interested
1	Having a conversation with someone	1	2	3	4	5	9
2	Talking on the phone	1	2	3	4	5	9
3	Singing or humming	1	2	3	4	5	9
4	Speaking to a group	1	2	3	4	5	9
5	Raising your voice to get someone's attention	1	2	3	4	5	9
6	Talking at a party or other noisy place	1	2	3	4	5	9
7	Talking while the TV is on	1	2	3	4	5	9
8	Talking in a restaurant	1	2	3	4	5	9
9	Talking in a car	1	2	3	4	5	9
10	Talking to someone in authority	1	2	3	4	5	9

SOB = Shortness of breath.

Table 2. Anthropometric characteristics, respiratory function, and speech and exertional dyspnea in 31 patients before and after the PRP and in the control group

	Age years	Sex F/M	Height m	Weight kg	BMI kg/m ²	VC %pred	FEV ₁ %pred	FEV ₁ /VC %	IC %pred	FRC %pred	TLC %pred	RV %pred
Before PRP	69 ± 7	13/18	1.65 ± 0.09	69 ± 18	25.1 ± 18.6	83 ± 28 (2.67 ± 0.85)	43 ± 17 (1.04 ± 0.45)	40 ± 13	81 ± 25 (1.88 ± 0.62)	147 ± 44 (4.61 ± 1.6)*	114 ± 25 (6.71 ± 1.68)**	159 ± 59 (3.59 ± 1.59)
After PRP		13/18				90 ± 33 (2.78 ± 0.89)	45 ± 17 (1.08 ± 0.44)	39 ± 12	85 ± 25 (1.99 ± 0.65)	132 ± 36 (4.25 ± 1.35)	106 ± 20 (6.31 ± 1.62)	143 ± 49 (3.67 ± 1.32)
Control group	75 ± 9	3/12	1.67 ± 0.07	70 ± 17	24.3 ± 5.2	86 ± 23 (2.93 ± 0.69)	47 ± 22 (1.04 ± 0.37)	37 ± 11	74 ± 18 (1.80 ± 0.86)	155 ± 35 (5.31 ± 1.51)	114 ± 17 (7.10 ± 1.54)	166 ± 52 (4.27 ± 1.54)

Values are means ± SD (liters). VC = Vital capacity; FEV₁ = forced expiratory volume in 1 s; IC = inspiratory capacity; TLC = total lung capacity; RV = residual volume. * p = 0.009 and ** p = 0.02 vs. after PRP.

tionnaire items was based on the breathlessness category during speech activity. The questionnaire was administered by an experimenter. A therapist asked the patients to rate their shortness of breath while performing the phonetic activities listed in table 1. Subjects were asked to rate their shortness of breath on a 5-point scale, 1 indicating that the activity was never associated with shortness of breath and 5 indicating activities that always caused shortness of breath, including those that the patients were unable to perform because of excessive breathlessness. Activities that the subject would not do, regardless of ability, were disregarded. In keeping with Lee et al. [1], category 9, i.e. 'not interested in doing this activity', was treated as missing data in the statistical analyses.

Protocol

All patients were tested immediately before and at the end of the PRP. Spirometry, lung volumes, arterial blood gas tensions, MRC scores, BDI/TDI, DS questionnaires, and the 6'WT were studied before and after the program.

Statistics

Values are means (± standard deviation) unless otherwise specified. Simple regression analysis was performed using Pearson's correlation coefficient. p < 0.05 was considered statistically significant. All statistical procedures were carried out using the StatGraphics Plus 3.1 statistical package (Manugistics, Rockville, Md., USA).

Results

The anthropometric characteristics of the patients are given in table 2. Three patients had a Body Mass Index (BMI) below the lower normal limit (15.2, 16.3, and 17.6 kg/m²) and 1 patient was morbidly obese (BMI = 42.1 kg/m²).

Fig. 1. Individual and mean changes in dyspnea scores in the study patients. Closed circles and bars represent means $\pm$ standard error.

Table 3. Speech and exertional dyspnea and 6-min walking distance before and after pulmonary rehabilitation

	6'WD m	MRC a.u.	BDI/TDI a.u.	DS % max
Before PRP	343 $\pm$ 156	3.23 $\pm$ 0.80	4.8 $\pm$ 2.9	60.3 $\pm$ 23.2
After PRP	375 $\pm$ 152	2.65 $\pm$ 0.80	2.0 $\pm$ 1.41	43.7 $\pm$ 19.7
p	<0.00001	<0.00001	–	<0.00001

Values are means $\pm$ SD. 6'WD = Walking distance obtained in 6 min; a.u. = arbitrary units.

Before PRP

Patients exhibited mild-to-very severe obstruction (table 2). MRC dyspnea averaged 3.23, the mean distance covered in 6 min was 343 m, and DS data, expressed as a percentage of the maximal potential DS score, averaged 60.3 (table 3). Individual and mean data expressed as a percentage of the maximal potential DS score ($5 \times 7 = 35 = 100\%$) are shown in figure 1.

In detail (fig. 2), the patients' response frequency (%) was 100% for items 1 and 5, 98% for item 2, 80% for item 4, and 60% for item 6. Singing (item 3) was an uncommon activity; only 9/31 patients commonly sung. Most of the patients (>50%) answered '9' (not interested) for items 7, 8, 9, and 10. In keeping with Lee et al. [1], category 9 data were treated as missing in the statistical analyses and are

not shown in figure 1. Figure 2 also shows control group DS data. Patients' response frequency (%) was 100% for items 1, 2, 5, and 6 and 93% for item 4. Singing (item 3) was an uncommon activity; only 5/15 patients commonly sung. Most of the control group (>50%) answered '9' (not interested) for items 7, 8, 9, and 10 so that category 9 data were treated as missing in the statistical analyses. None of the 5 DS scores changed after 4 weeks (from $p = 0.16$ to 0.34).

Effects of PRP

FRC decreased by 15% of the predicted value (table 2); a decrease was also found in total lung capacity and MRC score (table 3). Conversely, ERV did not change significantly (68.2 ± 33.1 vs. 72.5 ± 34.7 %pred, $p = 0.9$). The increase in 6'WT, though statistically significant (32 ± 37 m, $p < 0.00001$), was clinically meaningful (≥ 35 m) only in 14 patients.

A decrease in DS score was found in all but 4 patients (table 3; fig. 1), but a good outcome response was found in all patients.

Five DS item (1, 2, and 4–6) scores also decreased significantly (from $p = 0.0007$ to 0.038) (fig. 2). For items 3 and 7–10 the level of significance was not reached; this is presumably because less than one third of our patients engaged in that activity in daily life.

Correlations

At baseline the mean DS score weakly correlated with both 6'WT ($\rho = -0.41$, $p < 0.03$) and BDI ($\rho = -0.44$, $p < 0.04$), but not with lung volumes or MRC (table 4). The significant changes (Δ) in the DS score with the PRP (table 3) did not correlate with any of changes in volume, dyspnea questionnaires, or the 6'WT (table 4; fig. 3).

Discussion

The novel findings in this study are that DS proves responsive to a standard PRP and provides independent information that complements physiological data.

Critique of the Method

Only the speech section of the UCDQ was used because its physical activity questions are not in line with those of the widely used and amply validated questionnaires for assessing dyspnea during physical activity. Instead, in this study chronic exertional dyspnea was assessed using the classical MRC chronic dyspnea scale [9] and the BDI/TDI by Mahler et al. [14]. Although the

Fig. 2. Average changes in dyspnea scores for items 1, 2, and 4–6. Circles represent the study group; open circles indicate results before rehabilitation and closed symbols after rehabilitation. Squares represent the controls; open squares indicate the first visit and closed symbols the second visit 4 weeks later. Bars represent the standard error. NS = Not significant.

Fig. 3. Changes (Δ) in DS do not correlate with Δ6'WT.

Table 4. Spearman's correlation coefficients (rho) of the mean DS score to the MRC and BDI/TDI score and functional variables measured in 31 COPD patients

Respiratory variables	n	DS score			
		before PRP		after PRP	
		rho	p	rho	p
MRC dyspnea score, a.u.	31	0.21	0.26	0.27	0.14
BDI/TDI	31	-0.44	0.04	0.08	0.82
FEV ₁	31	-0.04	0.83	0.06	0.76
VC	31	0.01	0.95	-0.06	0.75
FEV ₁ /VC, %	31	0.08	0.69	0.13	0.51
FRC	31	0.12	0.56	0.10	0.64
IC	31	-0.18	0.38	-0.16	0.43
ERV	31	0.07	0.74	0.12	0.56
6'WD, m	29	-0.41	0.03	-0.34	0.07

Values are expressed as %pred unless otherwise stated. FEV₁ = Forced expiratory volume in 1 s; VC = vital capacity; IC = inspiratory capacity; 6'WD = walking distance obtained in 6 min; a.u. = arbitrary units.

UCDQ is a useful tool for detecting the presence and assessing the severity of DS, some of its questions may not be universally relevant because some subjects do not sing (item 3), go to restaurants (item 8), or have a car (item 9) or television set (item 7). Such questions may have fewer responders than other questions. Accordingly, only the high-response items (1, 2, and 4–6) were used in correlation with the MRC and BDI/TDI scores and the 6'WT at baseline and after PRP.

Physiological Background of DS

Phonatory tasks are associated with longer expiration and a larger lung volume excursion with lung deflation in healthy humans [2, 15, 16] in whom a decrease in EELV during phonation indicates substantial expiratory muscle tension [2, 15]. In fact, during many phonatory tasks EELV closely approaches the maximal expiratory flow-volume curve, and the flow required to speak can no longer be sustained because the maximal flows decrease along the maximal expiratory flow-volume curve [2]. These findings point out the importance of a large ERV and flow reserve for phonation. During speech, average airflow rates rarely exceed 0.5 liters/s [2, 15]. While healthy subjects can maintain flows of this degree, patients with severe airway obstruction may experience difficulty as they are flow limited even during while at rest [17]. These patients often break speech phrases probably

because they can maintain a flow rate only at higher lung volumes. The progressive expiratory muscle tension results in a dynamic airway compression distortion and collapse that can stimulate upper airway receptors to initiate vagal afferent impulses that contribute to dyspnea [3, 18].

Clinical Relevance of the Results

The first aim of the study was to investigate the responsiveness of DS to a standardized PRP. Our study shows for the first time that the UCDQ is a useful tool for assessing the effect of a PRP on DS. A significant improvement was found in all items (fig. 2), except for low-response item 3. The improvement in DS was associated with but independent of changes in respiratory function, MRC scores, and the 6'WT. We could not identify the mechanism underlying the improved DS with treatment. Changes in lung volume from baseline, namely FRC and ERV, did not correlate with change in DS. We postulate that these changes in lung volumes with treatment were too small to explain a noticeable improvement in phonatory activities.

The second aim of this study was to test whether and to what extent DS provides independent information that complements physiological data. If one considers the lack of association between DS, MRC, and TDI, as well as the clinical meaningless of the relationship of DS with both 6'WT (rho = 0.41) and BDI (rho = 0.46), a case can be made for DS indicating an independent dimension (outcome) in the clinical assessment of these patients. These results extend the data of Lee et al. [1], obtained in a smaller series of COPD patients whose functional lung data were not evaluated, and the data of Hodgev et al. [19], who did not assess the effect of treatment on DS in a larger series of patients with COPD.

In conclusion, the UCDQ is a useful tool for assessing the effect of a PRP on DS. Evidence of independent objective measurements supports the validity of routine a multivariable assessment including DS in patients with COPD. We also recommend monitoring DS, particularly in patients who rely extensively on speech for communication.

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