

RELATIONSHIP BETWEEN SPIROMETRY AND DYSPNOEA IN CHRONIC OBSTRUCTIVE PULMONARY DISEASE

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Abstract: *Spirometry is used for diagnosis of chronic obstructive pulmonary disease (COPD) and the staging of severity. Dyspnoea is a primary clinical feature of COPD. The aim of the study was to analyze the correlation between spirometry parameters (FEV1, FVC) and MRC dyspnoea grade, and correlation of FEV1, FVC with Borg dyspnoea scale before and after administration of bronchodilator (broncodilation reversibility test-BRT). In 52 patients with COPD we measured lung function parameters at baseline and 30 minutes after administration 0,2+0,08mcg of fenoterol ipratropium bromide (Berodual). We also assessed the level of dyspnea with the Modified 10-grade Borg's scale and MRC scale. After Berodual mean values of dyspnea and lung function parameters significantly improved. Dyspnea by MRC($r=-0,389$, $p>0,01$) and Borg ($r=-0,500$, $p<0,01$) correlated with spirometry parameters. According to this results score of dyspnoea is a good marker of greater disease severity.*

Key words: *chronic obstructive pulmonary disease, spirometry, dyspnoea, broncodilation reversibility test*

1. INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a significant cause of morbidity and mortality. The guidelines recommend spirometry for diagnosis of COPD and it is the most often used and easiest respiratory function test [1,2,3]. Bronchodilation reversibility test (BRT) is a pharmacodynamic test for obstruction reversibility assessment and it is part of respiratory function testing in COPD [4]. It is based on the comparison of the values of lung function parameters achieved in basal conditions with values achieved under the action of the bronchodilator. The indications for BRT: a) evaluate the best possible respiratory function of the patient; B) exclude asthma (better reversibility of obstruction); C) predict the course of the disease, because the post-bronchodilator values better show the prognosis than basal; D) anticipate the effect of the drug and make the right choice of the best therapeutic regimen; e) assess the effectiveness of the therapy. The test is performed in a stable state of patients with least moderate COPD, and the most commonly used bronchodilators are β_2 agonists and anticholinergics. In previous versions of the Global Initiative for Chronic Obstructive Pulmonary Disease (GOLD), a step-by-step approach to the treatment of COPD was recommended based on the value of the forced expiratory volume in the first second (FEV1), which was the only indicator for assessing the severity of the disease. Numerous clinical studies have shown that only FEV1 is not sufficient for the assessment of the severity of the disease, and a new approach to the treatment of COPD implies an analysis of disease symptoms, spirometric obstruction classification and evaluation of exacerbations.

Dyspnoea has been defined as a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity[5]. It is a symptom and is the result of a discrepancy between central respiratory motor activity and incoming afferent information from the receptors in the respiratory tract, lungs and structures of the chest wall [6,7,8]. As one of the most common symptoms of chronic obstructive pulmonary disease, it limits their physical activity and is among the main reasons for turning to a doctor [9,10,11].

In practice, direct measurement of dyspnoea is most often applied using different scales. Borg-Category Ratio scale requires the patient to ascribe a value representative of the magnitude of dyspnoea, ranging from 0 to 10 anchored with simple verbal descriptions of intensity such as “very, very slight” and “severe” [12,13]. It is simple and applicable in everyday practice and can be a method of choice to step up dyspnoea.

The second group of direct tests of dyspnoea based on the ability of the patient to perform a certain physical effort, or based on these measurements, the patient's suitability for certain life activities is assessed. The tests in this group are more adapted to clinical work. One of the most well-known tests in this group is the five-point scale of the Medical Research Council (MRC) [14].

2.AIMS

The aim of the research is to determine whether there is a correlation between spirometry results with dyspnoea measurements and their relationship after the BRT.

3.METHODOLOGY

In this prospective study, a group of 52 COPD patients in a stable phase of the disease was diagnosed according to the current guide (GOLD). The research was conducted in the Internal Department of the General Hospital Uzice in the period July 2015.- July 2017.

All subjects were given an exhaustive anamnesis and a physical examination was performed. In the history of all patients there was information about coughing, wheezing and / or progressive dyspnoea. The assessment of dyspnoea based on the ability of the patient to undergo a certain physical effort and condition of each patient before testing has been graded by the scale of the Medical Reserch Council (MRC) of 0-4.

Pulmonary function was tested with spirometry. All subjects had bronchodilatation reversibility test, which was negative. For the bronchodilatation test, pulmonary function parameters were determined 30 minutes after inhalation of the fixed combination phenoterol ipratropium bromide (Berodual) at a dose of 0.2 +0.08 mcg (4 breaths). A sense of changing the severity of breathing during the bronchodilatory test was determined using the Modified Borg Dyspnoea Level 0-10. An important change is the degree of dyspnoea for 1.

The flow-volume curve parameters, the forced expiration volume in the first second (FEV1) and the forced vital capacity (FVC), expressed in absolute value and percentages of the envisaged norm, were registered on Spirolab II. Prior to testing, respondents explained the purpose and method of testing, with their voluntary consent.

The values of the European Respiratory Society (ERS) from 1993 were used to evaluate the value.

The arithmetic mean, standard deviation (SD) and standard error (SE) was used to describe the obtained data for numerical features. Comparison of differences was made by the Pirson χ^2 test with non-parametric features, by Student's t-test for parametric features. Calculation of the correlation coefficient determined the correlation of the degree of dyspnoea with the parameters of the respiratory function obtained by spirometry. Database and statistical analysis were done in the appropriate commercial computer program.

4.RESULTS

The values of all parameters of the changeable variables are given before and after the BDT. Index code "b" indicates the parameter after the use of Berodual.

4.1. General characteristics

In the study population of 52 patients with COPD, the proportion of male was 41 (78.84%) compared to 11 female (22.16%). Other descriptive parameters are in the table 1.

Tabela 1. Descriptive parameters

Characteristics	Arithmetic mean	SD	SE
AGE	61,5961	8,9760	1,2447
HEIGH	169,6731	9,2561	1,2836
WEITH	77,3846	16,2314	2,2509
BMI	26,7508	4,2697	,5921

Chart 2. Distribution of smoking habit in a group of patients with COPD

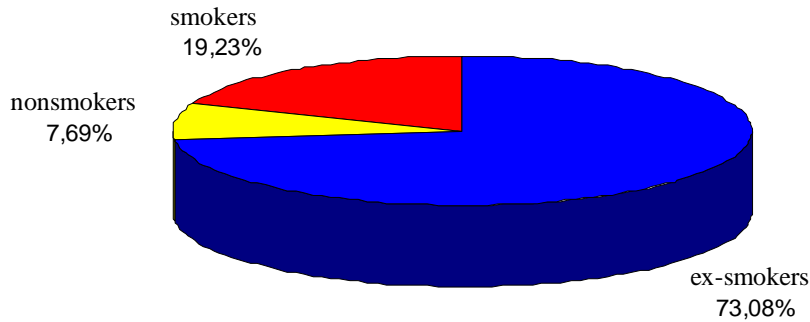


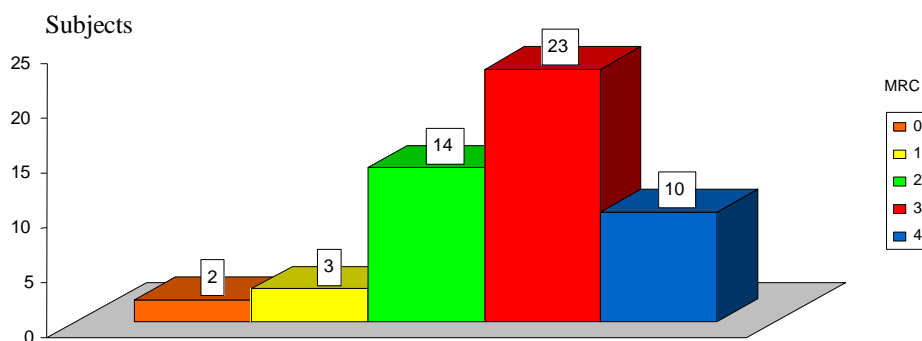
Chart 2 shows the presence of smoking habit- there were 4 (7,69%) non-smokers, 10 (19,23%) active smokers, but the highest number of ex-smokers was 38 (73,08%). Smoking intensity is 56.75 pack-years.

4.2 Dyspnoea and COPD

The average score of dyspnoea according to the MRC scale was 2.69 (SD 0.98). The average Borg dyspnea score of 4.09 (SD 2.21) after application of the bronchodilator dropped to 2.38 (SD 1.91). The distribution of all parameters was normal, as verified by the Kolmogorov Smirnov test ($z < 1.96$ and $p > 0.05$).

Charts 1-3 show the scores of dyspnoea obtained by the Medical Research Council (MRC) and the Modified Borg's Scale scale.

Chart 1. Dyspnoea according to MRC



An analysis of the frequency of our subjects according to MRC dyspnoea score showed that there was a statistically significant difference ($\chi^2 = 12,453$; $df = 5$; $p < 0,01$). This can be explained by the far greater presence of MRC findings 2 and 3 compared to others (they make up 71.1% of the findings within group).

The analysis of the frequency (chart 2) of our subjects according to Borg's initial dyspnoea showed that there was a statistically significant difference ($\chi^2 = 10.224$; $df = 8$; $p < 0.01$). This can be explained by the far greater presence of dyspnoea findings 3 to 5 compared to others (they make up a total of 59.6% of findings). Patients had at least a barely noticeably breathing difficulty (degree of dyspnoea = 0.5), while the maximum dyspnoea (10) was not recorded.. The maximum registered basal value of dyspnea was 9.

Chart 2. The initial dyspnoea according to Borg scale

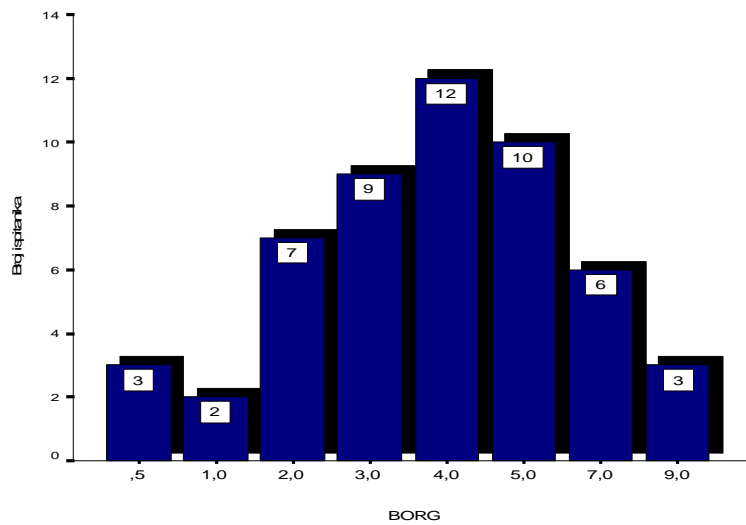
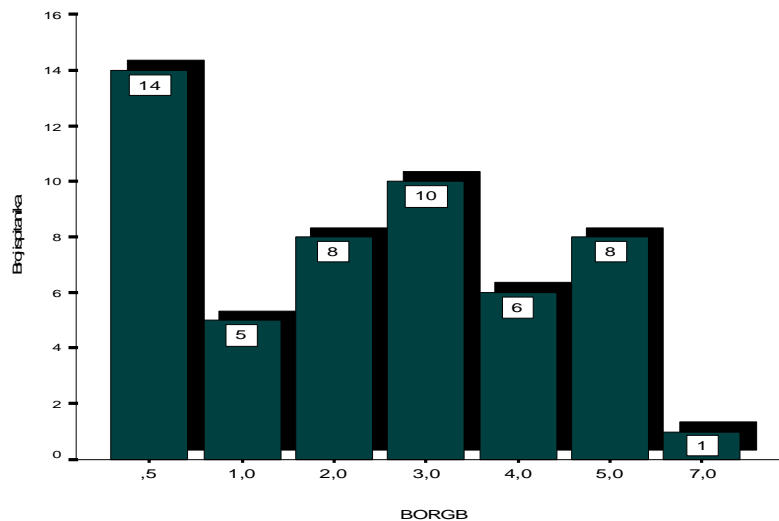


Chart 3. Distribution of Borg dyspnoea grade after Berodual



After administration of bronchodilator, the majority of subjects reduced the degree of dyspnoea. Only 3 (0.05%) subjects, who initially had a low dyspnoea score of 0.5, did not improve the sense of breathlessness. The analysis of the frequency of our respondents according to Borg's dyspnoea after Berodual showed statistically significant difference ($\chi^2 = 11,048$; df

= 8; $p < 0,01$). The highest number of respondents 14 (26.9%) had a score of 0.5 which is the lowest recorded value. The maximum dysfunction after bronchodilator use is 7.

4.3 Testing the breathing function

Descriptive parameters of our spirometric test subjects are shown in Table 2.

Table 2. Spirometric parameters of the subjects

Characteristics	N	Arithmetic mean	SD	SE
FVC	52	3,1137	,9667	,1341
FVC (%)	52	82,1538	20,8274	2,8882
FVC b	52	3,4908	1,0576	,1467
FVC b (%)	52	94,4615	20,8077	2,8855
FEV1	52	1,4640	,5276	7,316E-02
FEV1 (%)	52	49,8462	14,5297	2,0149
FEV1 b	52	1,6740	,5757	7,984E-02
FEV1 b(%)	52	57,3462	16,6332	2,3066
FEV1/FVC	52	47,3127	10,4290	1,4462
FEV1b/FVCb	52	48,7491	11,7360	1,6275

Table 3. Results of the test and significance of the difference for the observed features

Characteristics	T	DF	P
Borg – Borgb	12,443	51	,000**
FVC – FVCb	-8,379	51	,000**
FEV1(%)- FEV1b(%)	10,720	51	,000**
FEV1/FVC- FEV1b/FVCb	-2,115	51	,039*
FEV1- FEV1b	10,358	51	,000**

* $P < 0,05$ ** $p < 0,01$

An analysis of the change in the mean values of the numerical features of our patients before and after Berodual application showed statistically significant difference in all parameters. Further, FEV1, FEV1 / FVC were found to increase and decline of dyspnoea according to Borg.

4.4 Correlation analysis

Calculation of the correlation coefficient determined the correlation between dyspnoea and spirometry results.

Table 4. Correlations of dyspnoea according to MRC and FEV1

(N = 52 ** p <0.01)

Marks and correlation coefficient		MRC	FEV1
MRC	R		-.369(**)

In the analysis of the relationship between parameters, it has been shown that the MRC dyspnoea value have correlated with FEV1 (p <0.01). The pathway is negative, meaning that the FEV1 decrease leads to worsening dyspnoea.

Table 5. Correlations of dyspnoea by Borg and FEV1 before and after Berodual

(N = 52 ** p <0.01)

Characteristics and correlation coefficient		Borg	Borgb	FEV1	FEV1b
Borg	R		.894(**)	-.511(**)	-.521(**)
Borgb	R	.894(**)		-.500(**)	-.420(**)
FEV1	R	-.511(**)	-.500(**)		.968(**)
FEV1b	R	-.521(**)	-.420(**)	.968 (**)	

It was found that the dyspnoea value according to Borg before and after Berodual correlated with FEV1 before and after Berodual (p <0.01). The link is negative, which means that the reduction in FEV1 leads to an increase in dyspnoea.

Table 6. Correlations of dyspnoea by Borg and FVC before and after Berodual

(N = 52 * p <0.05)

Characteristics and correlation coefficient		Borg	Borgb	FVC	FVCb
Borg	r		.894(**)	-.323(*)	-.259(*)
Borgb	r	.894(**)		-.251(*)	-.209(**)
FVC	r	-.323(*)	-.251(*)		.952(**)
FVCb	r	-.259(*)	-.209(**)	.952 (**)	

5.DISCUSSION

Analyzing subjects by gender, a higher prevalence of COPD in male subjects was observed, which is in line with literature data, and is explained by increased exposure to risk factors, primarily smoking. Smoking is the most common individual risk factor for the emergence of COPD [15]. In the investigated group there were 48 (92.3%) smokers, 38 were ex-smokers (79.2%), while 10 (20.8%) were active. The fact that 4 (7,69%) of the patients never smoked indicates other etiological factors of this disease.

Despite efforts in prevention, the number of patients with COPD is constantly increasing. This is significantly contributed by a discreet, concealed, long asymptomatic course. Patients feel their respiratory problems differently [16]. There are great individual differences in the perception of dyspnoea, some overestimate its significance, while others underestimate it. The illness can have a long silent phase. The reasons for this can be in the organic and psychological sphere. Dyspnoea is considered a perception of the effort of respiratory muscles in inspiration. Sensation of dyspnoea enhances physical activity, increases breathing activity and energy consumption of breathing. The maximum force of the inspiratory muscles

is reduced. Expiratory muscles are included in the breathing cycle. The expiratory flow can't be increased infinitely, and the shortening of the inspirium is considered to be an important adaptation for limitation of the expiratory flow in COPD. Different chest tissue, different lung ventilation asynchronisms and fatigue of respiratory muscles are organic background for differences in dyspnoea [17,18]. Many emotional, cognitive and situational variables are significantly affected dyspnoea experience. People with COPD belong to an elderly population suffering from associated depression and anxiety [19,20,21], and may feel more breathless than it would be appropriate to organic changes. On the other hand, with the progression of dyspnoea, it starts to appear at rest, and over time, patients become accustomed to frequent respiratory problems, and the threshold of tolerance increases. In patients who develop obstruction and have frequent exacerbations, a tolerance develops over time, reducing the sensory component of dyspnoea [22].

Torres et al. have shown that women significantly more perceive dyspnoea than men with COPD of the same stage [23]. Most studies deny the association of dyspnoea with sex or the age of the patient [24]. In the study, high initial dyspnoea measured by Borg and MRC scale were recorded. The average dyspnoea value of the MRC scale was 2.73 and the modified Borg scale was 4.09. The bronchodilator significantly reduces the dyspnoea score by Borg to 2.38. Most patients gave a lower value of the Borg scale after the drug. The exception is 3 (0.05%) subjects with an initially low dyspnoea score of 0.5. Rebic and al. followed the change in the feeling of dyspnoea with Borg and VAS scales in patients with negative bronchodilation test. A significant decrease in dyspnoea was found despite negative BRT [25].

Most studies confirm dyspnoea as the best predictor of the quality of life in COPD [26,27,28,29]. A common conclusion is that the degree of dyspnoea predicts the general health of the patient more than the parameters of the lung function.

6. CONCLUSION

The study found that there is a relationship between the dyspnoea measured by the Medical Research Council (MRC) with FEV1. Also, there is a correlation between Borg dyspnoea before and after the application of bronchodilator with spirometric parameters. The correlation between the change of dyspnoea and the change of FEV1 after bronchodilatory testing was not significant.

It is concluded that there is a strong correlation between general condition of the patient, respiratory symptomatology and physical examination and spirometric parameters.

LITERATURE

- [1] GOLD. Global Strategy for Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease 2017, Global Initiative for Chronic Obstructive Lung Disease, Inc 2017 available at. <http://www.goldcopd.com>, update 2017.
- [2] Han, M.K., Kim, D., Mardon, R.: Spirometry utilization for COPD: how do we measure up?, *Chest* 132(2):403-9, 2007.
- [3] Bartolome, R.C.: Importance of spirometry in COPD and asthma, *Chest* 117:15S-19S, 2000.
- [4] Mannino, D., Diaz-Guzman, E., Buist, S.: Pre- and post-bronchodilator lung function as predictors of mortality in the Lung Health Study, *Respiratory Research* 12:136, 2011.
- [5] Von Leupoldt, A., Reijnders, T., Schuler, M., Wittmann, M., Jelusic, D., Schultz, K.: Validity of a Self-administered Questionnaire Version of the Transition Dyspnea Index in Patients with COPD, *COPD: Journal of Chronic Obstructive Pulmonary Disease* 14:1, 66, 2017.
- [6] Vermeulen, F., Garcia, G., Ninane, V., Laveneziana, P.: Activity limitation and exertional dyspnea in adult asthmatic patients: What do we know? *Respiratory Medicine* 117, 122-130, 2016.
- [7] Von Leupoldt, A., Dahme, B.: Differentiation between the sensory and affective dimension of dyspnea during resistive load breathing in normal subjects, *Chest* 128:3345-49, 2005.
- [8] O'Donnell, D.E., Webb, K.A., Harle, I., Neder, J.A.: Pharmacological management of breathlessness in COPD: recent advances and hopes for the future, *Expert Review of Respiratory Medicine* 10:7, 823-834, 2016.
- [9] Mewes, R., Rief, W., Kenn, K., Ried, J., Stenzel, N.: Psychological predictors for health-related quality of life and disability in persons with chronic obstructive pulmonary disease (COPD), *Psychology & Health* 31:4, 470-486, 2016.
- [10] Antoniu, S.A.: Descriptors of dyspnea in obstructive lung diseases, *Multidisciplinary Respiratory Medicine* 5:216, 2010.
- [11] Laveneziana, P., Guenette, A.J., Webb, K.A., O'Donnell, D.E.: New physiological insights into dyspnea and exercise intolerance in chronic obstructive pulmonary disease patients, *Expert Review of Respiratory Medicine* 2012.
- [12] Borg, G.: Psychophysical bases of perceived exertion *Medical Science in Sports and Exercise*, 14 : 377-381, 1982.
- [13] Kendrik, K.R., Baxi, C.S., Smith, M.R.: Usefulness of the modified 0-10 Borg scale in assessing the degree of dyspnea in patients with COPD and asthma, *J Emerg Nurs* , 26(3)216-22, 2000.

- [14] Bhanurekha, B. Sasisekhar, T. Saireddy, Y. Indrakeela Girish, M. : Correlation of MRC Dyspnoea Scale and Forced Expiratory Volume in First Second (FEV1) In Chronic Obstructive Pulmonary Diseases, *Journal of Dental and Medical Sciences* 7(3), 2013.
- [15] Tamimi, A. Serdarevic, Dz. Hanania, N.: The effects of cigarette smoke on airway inflammation in asthma and COPD: Therapeutic implications, *Respiratory Medicine* 106(3)319-28,2012.
- [16] Faryniarz, K. Tomlinson D et al.: Impact of dyspnea and physiologic function of general health status in patient with COPD, *Chest* 102(2):395-401, 1992.
- [17] O'Donnell, D.E.: Hyperinflation, dyspnea, and exercise intolerance in chronic obstructive pulmonary disease, *Proc Am Thorac Soc.* 2006
- [18] Thomas, M. Decramer, M. O'Donnell, D.E.: No room to breathe: the importance of lung hyperinflation in COPD, *Primary Care Respiratory Journal* 22:1, 101-111, 2013
- [19] Livermore, K. Sharpe, L. McKenzie, D.: Panic attacks and panic disorder in chronic obstructive pulmonary disease: A cognitive behavioral perspective, *Respiratory Medicine* 104:9, 1246-1253, 2010.
- [20] Von Leupoldt, A. Taube, K. Lehmann, K. Fritzsche, A. Magnussen, H.:The Impact of Anxiety and Depression on Outcomes of Pulmonary Rehabilitation in Patients With COPD. *Chest* 140:3, 730-736, 2011.
- [21] Kunik, M.E. Roundy, K. Veazey, C. Soucek, J. Richardson, P. Wray, N.P. Stanley, M.A.: Surprisingly high prevalence of anxiety and depression in chronic breathing disorders, *Chest* 127:1205-11, 2005.
- [22] Gonzales, C. Herrejon, A. Inchaurrega, I. et al.: Relationship between dyspnea and quality of life with body mass index and pulmonary function in the patients with COPD and emphysema, *Med Clin* 117(10):370-1, 2001.
- [23] Torres, J.P. Casanova, C. Garcini, A.M. et al. Respiratory factors associated with dyspnea in woman with COPD *Congres 2006;806S: E4663*
- [24] Thoracic American Society: Dyspnea. Mechanismus, assesment and managment: a consensus statement, *Am J Respir Crit Care Med* 159: 321-340, 1999.
- [25] Rebić, P. Žugić, V., Milenković, B.: Borg score (BS) and visual analogue scale (VAS) change during a negative bronchodilator response test in COPD, *World Congres on Lung Health and 10 European Society Congres, Firenze. Eur Respir J* 16(Suppl 31)314s, 2000.
- [26] Von Leupoldt, A. Balewski, S. Petersen, S. et al. Verbal descriptors of dyspnea in patients with COPD at different intensity levels of dyspnea, *Chest* 132:141–147, 2007.
- [27] Cvok, T. Milenkovic, B. Rebic, P.: Correlation of dyspnea and physiological impairment in COPD exacerbation , *ERS International Congres London, 2016.*
- [28] Koichi, N. Takateru, I. Mitsuhiro, T. Toru, O.: Dyspnea is a better predictor of 5-year survival than airway obstruction in patients with COPD, *Chest* 121:1434-1440, 2002.
- [29] Martinez, F.J. Donohue, J. Rennard, S.: The future of chronic obstructive pulmonary disease treatment—difficulties of and barriers to drug development, *The Lancet* 378:9795, 1027-1037, 2011.

APPENDIX

MRC Dyspnoea Scale	
grade	Degree of breathlessness related to activity
0	Not troubled by breatheless except on strenuous exercise
1	Short on breath when hurrying on a level or when walking up a slight hill
2	Walks slower than most people on the level, stops after a mile or so , or stops after 15 minutes walking at own pace
3	Stops for breath after walking 100 yards or after a few minutes on level ground
4	Too breathless to leave the house, or breathless when dressing/undressing
Modified Borg dyspnoea scale	

grade	Shortness of breath
0	Nothing at all
0,5	Very, very slight (just noticeable)
1	Very slight
2	Slight
3	Moderate
4	Somewhat severe
5	Severe
6	
7	Very severe
8	
9	Very, very severe (almost maximal)
10	Maximal