

# The Peculiarities of Six-Minute Walk Test in Patients with Chronic Obstructive Pulmonary Disease, Some with Normal Weight and Some Overweight

Evgeniy S. Ovsyannikov\*, Andrey V. Budnevsky, Lilia A. Titova,  
Anastasia S. Ivanova, Anastasia S. Kachur

*Voronezh State Medical University named after N.N. Burdenko  
Voronezh, Russia*

## Abstract

**Background:** The combination of chronic obstructive pulmonary disease (COPD) and overweight/obesity is a common clinical situation in modern healthcare. The objective of this study was to conduct a comparative analysis of exercise tolerance in normal body weight (NBW) and overweight patients with COPD in the 6MWT using the original device for cardiorespiratory analysis and a method for assessing the cardiorespiratory condition.

**Methods and Results:** The study included 194 patients with COPD. The patients were divided into two groups. Group 1 consisted of 96 COPD patients with NBW: 77(80.21%) men and 19(19.79%) women aged 41 to 73 years (mean age of  $63.33 \pm 8.44$  years). Group 2 consisted of 98 overweight COPD patients: 74(75.51%) men and 24(24.49%) women aged 55 to 71 (mean age of  $64.84 \pm 5.46$  years). To assess tolerance to physical activity and to objectify the functional status of patients, the 6MWT was used and carried out according to generally accepted principles. The distance covered in 6 minutes (6MWD) was measured in meters and compared with the proper 6MWD(i). The developed device for cardiorespiratory analysis was used to obtain the most accurate 6MWT result. All patients in the study groups underwent an analysis of the composition of the body by the bioelectrical impedance method using a fat mass analyzer BC-555 (Tanita Corporation, Tokyo, Japan). The percentages of fat, water, muscle mass (MM), and bone mass were evaluated.

The average value of the 6MWD/6MWD(i) ratio in COPD patients with NBW was significantly lower than in COPD patients with overweight ( $P=0.0121$ ). Before the test, the study groups did not differ in the level of  $SpO_2$ . However, according to the results of comparative analysis, this parameter was significantly lower in patients with NBW immediately after the 6MWT ( $P=0.0000$ ), which, along with a lower value of the distance traveled as a percentage of the proper value in Group 1 patients, may indicate a lower tolerance to physical activity in COPD patients with NBW than in patients with overweight. In COPD patients with NBW, the percentage of fat and MM were significantly lower than in COPD patients with overweight ( $P=0.0000$  in both cases). There was a direct correlation between 6MWD and body mass index ( $r=0.56$ ,  $P=0.003$ ) and between 6MWD and MM percentage ( $r=0.59$ ,  $P=0.016$ ).

**Conclusion:** Higher exercise tolerance is found in overweight COPD patients than in COPD patients with NBW. This phenomenon can be explained to some extent by the compositional components of the body, in particular, by a significantly lower percentage of lean MM in patients with NBW. (*International Journal of Biomedicine*. 2022;12(4):530-534.).

**Keywords:** chronic obstructive pulmonary disease • overweight • six-minute walk test

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## Abbreviations

**6MWT**, six-minute walk test; **BMI**, body mass index; **COPD**, chronic obstructive pulmonary disease; **HR**, heart rate; **HC**, hip circumference; **MM**, muscle mass; **NBW**, normal body weight; **WC**, waist circumference.

## Introduction

The combination of chronic obstructive pulmonary disease (COPD) and overweight/obesity is a common clinical situation in modern healthcare.<sup>(1)</sup> Over the past decade, a significant prevalence of obesity among COPD patients, compared with the general population of patients, has been established, which is one of the urgent problems of medicine.<sup>(2)</sup> Due to the significant increase in the prevalence of this combination of diseases, it is necessary to evaluate possible outcomes in patients with COPD and obesity.<sup>(1)</sup>

Obesity in non-COPD patients impacts lung function and is associated with dyspnea and reduced exercise capacity.<sup>(1)</sup> Also, the presence of obesity in COPD patients is accompanied by a more pronounced decrease in physical activity and an increase in the frequency of hospitalizations, in contrast to COPD patients with normal body weight (NBW).<sup>(3)</sup>

However, recent studies have shown that COPD patients with overweight/obese who have a higher lean MM have an advantage in terms of survival compared to non-obese patients.<sup>(1,3)</sup> In addition, it should be noted that COPD patients with a higher BMI may more often experience shortness of breath and activity restrictions, but it has been found that they have a relatively greater tolerance for physical activity than patients with normal BMI; however, the reason for this is not fully understood.<sup>(1,2)</sup>

Currently, spirometry is the main method of diagnosing COPD GOLD, 2021).<sup>(3)</sup> However, spirometry data do not entail an assessment of changes in patient's quality of life with COPD and weakly correlate with the severity of shortness of breath, exercise tolerance, and general health.<sup>(2,4)</sup> A simple and reproducible 6MWT can be used to determine additional functional criteria, such as exercise tolerance.<sup>(5)</sup>

The objective of this study was to conduct a comparative analysis of exercise tolerance in NBW and overweight patients with COPD in the 6MWT using the original device for cardiorespiratory analysis and a method for assessing the cardiorespiratory condition.

## Materials and Methods

The study included 194 patients with COPD (GOLD 3-4, group D). The diagnosis of COPD was established in accordance with GOLD, revision 2021, based on a comprehensive assessment of the symptoms of the disease, anamnesis data, objective status data, and spirometry.<sup>(5)</sup> The patients were divided into two groups. Group 1 consisted of 96 COPD patients with NBW: 77(80.21%) men and 19(19.79%) women aged 41 to 73 years (mean age of 63.33±8.44 years). Group 2 consisted of 98 overweight COPD patients: 74(75.51%) men and 24(24.49%) women aged 55 to 71 (mean age of 64.84±5.46 years). The presence of normal or overweight was determined by BMI. 18.5-24.99 kg/m<sup>2</sup> – NBW, 25.0-29.99 kg/m<sup>2</sup> – overweight.

The criteria for exclusion from the study were: 1) participation of the patient in any intervention study, 2) COPD in the acute stage, 3) concomitant diseases of the lungs, 4) concomitant diseases of other organs and systems, such as acute cardiac pathology, chronic heart insufficiency

with reduced ejection fraction, and chronic renal or hepatic insufficiency.

To assess tolerance to physical activity and to objectify the functional status of patients, the 6MWT was used and carried out according to generally accepted principles. The distance covered in 6 minutes (6MWD) was measured in meters and compared with the proper 6MWD(i). The 6MWD(i) was calculated according to the formulas, which consider age and BMI. The value of 6MWD(i) for men:  $6MWD(i) = 1,140 \text{ m} - (5.61 \times \text{BMI}) - (6.94 \times \text{age})$ . The value of 6MWD (i) for women:  $6MWD (i) = 1,017 \text{ m} - (6.24 \times \text{BMI}) - (5.83 \times \text{age})$ .<sup>(6)</sup>

In addition, we solved the problem of creating a device that gives the most accurate 6MWT result, ensuring its high safety. The device for cardiorespiratory analysis that we developed contains a housing with a control unit and an infrared pulse oximetry sensor mounted on it to measure the pulse rate and blood oxygenation. The body of the device is made in the form of a telescopic cane equipped with a handle. At the end of the cane, there is a wheel block in the form of a wheel and a sensor for counting wheel revolutions attached to it. When a submaximal HR (75% of the maximum for a given age) is reached or the oxygen saturation level decreases (<86%), a warning message appears on the device screen, and the test stops. An increase in the accuracy of measurements is achieved in the process of conducting a study and assessing the dynamics of changes in the parameters of the cardiovascular and respiratory systems when performing a test with a load.<sup>(7)</sup> All patients in the study groups underwent an analysis of the composition of the body by the bioelectrical impedance method using a fat mass analyzer BC-555 (Tanita Corporation, Tokyo, Japan). The percentages of fat, water, MM, and bone mass were evaluated.

The study was conducted in accordance with ethical principles of the WMA Declaration of Helsinki (1964, ed. 2013) and approved by the Ethics Committee of Voronezh State Medical University named after N. N. Burdenko. Written informed consent was obtained from all participants.

Statistical analysis was performed using STATGRAPHICS Plus 5.1. For descriptive analysis, results were presented as mean±standard deviation (SD). Inter-group comparisons were performed using One-Way ANOVA. Group comparisons with respect to categorical variables were performed using chi-square test. Pearson's correlation coefficient (r) was used to determine the strength of the relationship between the two continuous variables. A probability value of  $P < 0.05$  was considered statistically significant.

## Results

Groups 1 and 2 were comparable in sex ( $P=0.0817$ ) and age ( $P=0.17$ ), as well as in relation to the use of long-acting anticholinergic drugs ( $P=0.12$ ), long-acting  $\beta_2$ -agonists ( $P=0.15$ ), inhaled corticosteroids ( $P=0.53$ ), and short-acting  $\beta_2$ -agonists ( $P=0.19$ ).

The results of the 6MWT are presented in Table 1. The distance in the 6MWT in COPD patients NBW was less than

in COPD overweight patients, but the differences were not statistically significant ( $P=0.7205$ ). At the same time, the average value of the 6MWD/6MWD(i) ratio in COPD patients with NBW was significantly lower than in COPD patients with overweight ( $P=0.0121$ ).

**Table 1.**

**The results of the 6MWT of COPD patients in the study groups.**

Parameter	Group 1	Group 2	P-value
6MWD, m	252.68±184.44	261.35±151.21	0.7205
6MWD, % of predicted	43.09±30.53	49.78±26.93	0.0121
HR before the test, bpm	87.1±16.2	86.8±18.3	0.9038
HR after the test, bpm	108.3±18.2	116.1±15.8	0.0017
SpO <sub>2</sub> before the test, %	94.7±3.4	93.9±2.5	0.0630
SpO <sub>2</sub> after the test, %	88.3±3.2	93.1±3.4	0.0000

**Table 2.**

**The compositional components of the body of COPD patients in the study groups.**

Parameter	Group 1	Group 2	P-value
BMI, kg/m <sup>2</sup>	23.02±1.97	27.95±1.53	0.0000
% of fat	16.75±7.85	22.44±11.92	0.0001
% of MM	47.78±9.54	56.53±9.76	0.0000
% of water	54.38±4.94	47.19±4.55	0.0000
% of bone mass	4.19±1.05	3.25±1.61	0.0000
WC, cm	87.93±14.09	95.34±16.28	0.0009
HC, cm	96.30±5.35	92.74±23.68	0.1522
WC/HC	0.92±0.14	1.15±0.46	0.0000

Heart rate values in patients in the study groups did not significantly differ before and immediately after the test. At the same time, the average value of the heart rate in COPD patients with NBW was significantly lower than in COPD patients with overweight ( $P=0.0017$ ). At the same time, no excess of submaximal values of this parameter was recorded in any of the subjects during the 6MWT by the device.

Before the test, the study groups did not differ in the level of SpO<sub>2</sub>. However, according to the results of comparative analysis, this parameter was significantly lower in patients with NBW immediately after the 6MWT ( $P=0.0000$ ), which, along with a lower value of the distance traveled as a percentage of the proper value in Group 1 patients, may indicate a lower tolerance to physical activity in COPD patients with NBW than in patients with overweight.

The results of a comparative analysis of the compositional components of the body of COPD patients in the study groups, as well as the data of an anthropometric study with the determination of BMI, hip circumference (HC),

waist circumference (WC), and their ratios, are presented in Table 2. Thus, in COPD patients with NBW, the percentage of fat and MM were significantly lower than in COPD patients with overweight. The same applies to WC and WC/HC, but not HC, which was unreliably even higher in COPD patients with NBW. At the same time, there was a direct correlation between 6MWD and BMI ( $r=0.56$ ,  $P=0.003$ ) and between 6MWD and MM percentage ( $r=0.59$ ,  $P=0.016$ ).

## Discussion

In recent years, the relationship between COPD and overweight/obesity has become one of the most discussed problems. It is noted that an increased risk of obesity in COPD patients may be due to a decrease in physical activity and physical performance, both as a result of long-term use of corticosteroids<sup>(8)</sup> and due to the presence of one of the main manifestations of the disease in a patient – shortness of breath.<sup>(9)</sup> Concomitant diseases,<sup>(10,11)</sup> hormonal disorders,<sup>(12)</sup> and metabolic disorders<sup>(13)</sup> can play a significant role in the formation of obesity in COPD, which, in combination with additional factors, such as smoking and a sedentary lifestyle, form a patient's reluctance to engage in any type of physical activity.<sup>(9)</sup> An interesting fact is that many studies that evaluated the effect of overweight/obesity on mortality in COPD were reduced to the same result: higher mortality risks were observed in COPD patients with NBW than in COPD patients with overweight/obesity, as a result of which this phenomenon was called “the obesity paradox.”<sup>(1,8)</sup> It is important to mention that “obesity,” regarded in this context in terms of BMI, cannot serve as an accurate indicator, since it only takes into account body weight, without taking into account the amount of metabolically and functionally active fat-free mass, or lean MM.<sup>(1,8)</sup> One of several theories explaining the “obesity paradox” in one way or another is based precisely on the definition of MM. Its essence lies in the fact that the presence of greater MM in obese patients allows them to better adapt during exacerbations of COPD. Patients with overweight/obesity initially have a greater resource of lean MM and therefore, better tolerate its loss, resulting in their higher chances of survival than COPD patients with NBW.<sup>(1)</sup> Our study confirmed the fact that the MM percentage in COPD patients with obesity was significantly higher than in COPD patients with NBW. Lean body mass in obese people also has several other benefits, including protection from oxidative and inflammatory stress, affecting the prognosis of COPD patients.<sup>(1)</sup>

According to GOLD 2021, objectively proven impaired exercise tolerance can be attributed to important predictive factors for assessing the risk of adverse outcomes, and various characteristics of the methods (their simplicity/complexity, availability for implementation at various levels of medical institutions) do not play a role. Thus, it is possible to carry out both simple walking tests, which are easily implemented in the conditions of any medical institution, and complex cardiopulmonary testing in a specialized laboratory. The simplest and most standardized test for assessing the functional physical performance of patients with chronic

respiratory diseases is the 6MWT. It acts as a key study, providing the functional, therapeutic response, and prognostic data. Special training of personnel is not required to perform the 6MWT, which is one of the advantages of this test. In addition, it is considered quite safe and well tolerated by most patients, regardless of the stage of the disease.<sup>(14)</sup> It is noted in the literature that complications of 6MWT are extremely rare. Various severe symptoms (severe shortness of breath, dizziness, fatigue, chest pain, pain in the legs, a decrease in oxygen saturation to 80%-86%, etc.) may cause termination of the study, but they are not complications.<sup>(15)</sup> Various parameters are assessed during the 6MWT, including the level of SpO<sub>2</sub>, which allows an assessment of oxygen desaturation as a result of exercise. There is a direct correlation between the degree of decrease in SpO<sub>2</sub> and the severity of the disease. The clinical significance of desaturation is undoubted since it is associated with impaired daily physical activity, a faster decrease in FEV1, and, as a result, the progression of COPD and a worse prognosis of the disease.<sup>(16)</sup> One of the most important criteria for the reliability of SpO<sub>2</sub> measurements is obtaining an adequate signal. In this regard, there is a need to develop and introduce into everyday practice devices that can reliably fix the signal and continuously receive information from a specific sensor during the 6MWT. The device that we have developed meets the stated requirements.

During the 6MWT, the HR is also assessed (before and at the end of the test). An important point is the definition of such a parameter as the restoration of HR, that is, a decrease in HR at rest after the end of the 6MWT. The results of some studies conducted among patients with pulmonary arterial hypertension indicate that insufficiently rapid recovery of HR within the first minute after the end of the 6MWT was associated with negative outcomes (in particular, with high mortality).<sup>(17)</sup>

Thus, in order to ensure maximum safety of testing with the 6MWT, it is necessary to record and evaluate SpO<sub>2</sub> and HR. The cardiorespiratory analysis device we developed has this capability, while it also automatically monitors the distance traveled, which is the optimal solution to the task.

It should be noted that the distance in meters, covered in 6 minutes, is the main result of the 6MWT, characterized by the presence of a close relationship with clinical outcomes in patients with COPD. Recently, the development and application of proper values of 6MWD have become the most relevant that require further study.<sup>(18)</sup> In our study, we supplemented the standard 6MWD with the ratio 6MWD/6MWD (i), expressed in percentage, and reflected its significance in the form of reliable detection of differences in the results of 6MWT in COPD patients with NBW or overweight.

**In conclusion**, one of the main tests for assessing exercise tolerance among COPD patients (of any BMI) is the simple and safe 6MWT. The device we have created allows us to achieve more accurate test results while working in automatic mode with continuous monitoring of the following parameters: HR and oxygen saturation. This feature of the device allows, if necessary, notifying the doctor and the patient about the forced termination of the test. Taking into account the data obtained and presented in this study, it seems reasonable

to compare the actual distance traveled by the patient in meters with the proper indicator depending on gender and BMI, expressed as a percentage, when conducting 6MWT. Higher exercise tolerance is found in overweight COPD patients than in COPD patients with NBW. This phenomenon can be explained to some extent by the compositional components of the body, in particular, by a significantly lower percentage of lean MM in patients with NBW. This fact must be considered when compiling complex pulmonary rehabilitation programs for this group of patients,<sup>(19)</sup> which should include individual recommendations on physical training and nutrition to eliminate the described imbalance.

## Competing Interests

The authors declare that they have no competing interests.

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\*Corresponding author: Prof. Evgeniy S. Ovsyannikov, PhD, ScD, Department of Faculty Therapy, Voronezh State Medical University named after N.N. Burdenko, Voronezh, Russia. E-mail: [ovses@yandex.ru](mailto:ovses@yandex.ru)

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