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The Comparison of Inspiratory Muscle Training Effectiveness in COPD Patients with Obesity and Normal Weight

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Abstract

The objective of this study was to compare the effectiveness of inspiratory muscle training in COPD patients with obesity and patients with normal body weight.

Materials and Methods: The study involved 2 groups of patients with COPD (clinical Group D) similar in spirometric parameters with signs of airflow limitation on spirometry (FEV_1<50% of predicted, a post-bronchodilator FEV_1/FVC ratio<70% of predicted). Group 1 consisted of 45 obese COPD patients (BMI>30 kg/m^2). Group 2 included 44 COPD patients with normal body weight (BMI from 18.5 kg/m^2 to 24.9 kg/m^2). The groups were comparable in age, gender, severity of bronchial obstruction, concomitant pathology, and drug therapy. All patients underwent IMT for 8 weeks. Breathe-Link Live Feedback Software was used to evaluate such parameter as SI (Strength Index), PIF (Peak Inspiratory Flow), Average Pressure, Average Power, Average Flow, Average Volume for the entire sessions were estimated. At the baseline and after 8 weeks all patients underwent an assessment of the lung function using spirometry (including FVC, FEV_1), and the severity of dyspnea using the mMRC questionnaire (The Modified Medical Research Council).

Results: A comparative analysis of the estimated parameters of training sessions showed a significant increase in SI, PIF, Average Power, and Average Flow in patients of Group 1. In patients of Group 2, we found only a tendency to be increased in these parameters, with the exception of Average Flow. A statistically significant increase in the FEV_1 and FVC parameters was observed only in Group 1. Statistical analysis showed a close correlation between the SI and the severity of dyspnea on the mMRC scale ($r=-0.52$, $P<0.05$) in Group 1.

Conclusion: The results of our study indicate a positive effect of IMT in patients with COPD, and a greater effect in patients with obesity than in those with normal body weight. Clinically, an improvement in the IMT parameters was expressed in a decrease in dyspnea and an improvement in spirometric indicators. (**International Journal of Biomedicine. 2019;9(4):304-307.**)

Key Words: chronic obstructive pulmonary disease • obesity • inspiratory muscle training

Abbreviations

6MWT, the 6-minute walk test; **BMI**, body mass index; **COPD**, chronic obstructive pulmonary disease; **FVC**, forced vital capacity; **FEF**, forced expiratory flow; **IMT**, inspiratory muscle training; **PR**, pulmonary rehabilitation; **QL**, quality of life.

Introduction

COPD is a widespread disease that significantly affects QL of patients; exacerbations and worsening of the disease course are one of the main reasons for hospitalization, largely determining the prognosis.[1] Despite the success of medical treatment for COPD, many patients continue to notice symptoms of the disease, such as progressive dyspnea, cough, and poor exercise tolerance.[2] Muscle dysfunction in COPD, the most extensively studied systemic manifestation of the disease, can involve both respiratory and peripheral muscles.[3-6] It is considered to be of multifactorial origin, with local and systemic factors interacting to modify, in different ways, the phenotype and function of any specific muscle.[7,8] Both pulmonary hyperinflation and

increased airway resistance increase the work of breathing, which is mainly dependent on inspiratory muscles.[8] Like other striated muscles in the whole body, respiratory muscles can also be influenced by systemic factors, such as inflammation and oxidative stress, nutritional depletion and the effect of certain drugs used in COPD treatment.[7,9-14] According to GOLD (2018), much attention is paid to PR programs that include physical training, especially of the muscles of the upper shoulder girdle and respiratory muscles, which have been shown to reduce the severity of the clinical disease course, the frequency of exacerbations, and hospitalizations.[1,15] A recent meta-analysis showed that only the use of IMT in patients with moderate and severe COPD led to a significant reduction in the severity of dyspnea. In addition, these patients showed an improvement in exercise tolerance.[16] Thus, IMT can be considered as an addition to treatment in patients with COPD who cannot fully participate in general physical training due to the presence of a concomitant pathology. In the available literature, however, there is very little information about the effectiveness of IMT in patients with COPD and obesity. Nevertheless, this component of the PR program in patients with COPD and obesity may be the most effective and preferred, given the impossibility of providing adequate exercise regimes due to the presence of a concomitant pathology of the cardiovascular system, which is more common in COPD patients with obesity than in COPD patients with normal body weight.

The objective of this study was to compare the effectiveness of inspiratory muscle training (IMT) in COPD patients with obesity and patients with normal body weight.

Materials and Methods

The study involved 2 groups of patients with COPD (clinical Group D) (average age of 63.5±7.2 years), similar in spirometric parameters with signs of airflow limitation on spirometry (FEV_1<50% of predicted, a post-bronchodilator FEV_1/FVC ratio<70% of predicted). Group 1 consisted of 45 obese COPD patients (BMI>30 kg/m^2). Group 2 included 44 COPD patients with normal body weight (BMI from 18.5 kg/m^2 to 24.9 kg/m^2). The groups were comparable in age, gender, severity of bronchial obstruction, and concomitant pathology. Exclusion criteria were cardiovascular diseases with increased LVEDP, a need for oxygen support, COPD exacerbation within 1 month, a history of spontaneous pneumothorax, signs of bullous disease in X-ray examination, severe osteoporosis combined with a history of spontaneous fracture of the ribs, lung surgery, and damage of the tympanic membrane.

All patients were familiarized with the IMT program; no additional regular physical exercises were prescribed to anyone. None of the patients had contraindications or restrictions for IMT using a breathing trainer. All patients received long-acting bronchodilators and inhaled glucocorticosteroids on a regular basis.

Respiratory muscles were trained using the POWERbreathe K5 breathing simulator (POWERbreathe International Ltd., Southam, England, United Kingdom).[17] The patient was in a sitting position, the air outlet through the nose when performing a breathing maneuver was blocked with a nasal clip. Training began with a warm-up for 1 minute at 50% of the expected full load. Then a training session was held, consisting of 30 breaths through the device with a certain resistance. Training was terminated upon completion of the program or upon the appearance of undesirable symptoms—cough, dyspnea, feeling of severe tiredness, and pain in the chest. In order to ensure safety during training sessions, oxygen saturation was monitored. Training sessions were performed 3 times a week for 8 weeks. Breathe-Link Live Feedback Software (POWERbreathe International Ltd., Southam, England, United Kingdom) was used to evaluate a number of parameters:

- SI (Strength Index) is an indicator of the strength of the respiratory muscles obtained from the peak inspiratory flow, namely the predicted value of maximum inspiratory pressure. In contrast to PImax (maximum inspiratory mouth pressure), dynamic assessment allows for the evaluation of inspiratory muscle output throughout the total lung volume. This is considered more appropriate for measuring inspiratory muscle performance than isometric assessments. The POWERbreathe has been validated, and its accuracy to measure dynamic inspiratory muscle pressure has been demonstrated. Pressure is plotted at every moment throughout each lung volume, which creates a line through IMT. The highest point in this line is called the SI. The use of the SI in clinical practice is preferable, especially with the integration of this parameter into automated IMT programs using modern electronic devices.
- PIF (Peak Inspiratory Flow) is an indicator that reflects the ability of the respiratory muscles to contract rapidly and overcome the natural resistance and elasticity of the respiratory system.
- Average Pressure for the entire session: represents the average pressure created in the airways due to the force of the inspiratory muscles during training.
- Average Flow for the entire session: represents the average flow generated in the airways due to the force of the respiratory muscles during training.
- Average Power for the entire session: represents the average power of muscle activity, which combines strength and speed (pressure×flow), averaged for individual breaths of the session.
- Average Volume for the entire session: this is a measure of the average amount of air that was inhaled during training.

In addition, at the baseline and after 8 weeks all patients underwent an assessment of the lung function using spirometry (including FVC, FEV_1), and the severity of dyspnea using the mMRC questionnaire (The Modified Medical Research Council). All tests were carried out by the same researcher without knowledge of a group affiliation (participants were blinded).

The study was carried out in compliance with Ethical Principles for Medical Research Involving Human Subjects, Adopted by the 18th WMA General Assembly, Helsinki, Finland, June 1964, and amended by the 52nd WMA General Assembly, Edinburgh, Scotland, October 2000. The study was

approved by the Ethics Committee of Voronezh State Medical University. Written informed consent was obtained from each patient.

All data was evaluated with STATGRAPHICS Plus 5.1. The normality of distribution of continuous variables was tested by the Kolmogorov-Smirnov test with the Lilliefors correction and Shapiro-Wilk test. Baseline characteristics were summarized as frequencies and percentages for categorical variables and as mean±SD for continuous variables. Student's unpaired and paired t-tests were used to compare two groups for data with normal distribution. 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 and Discussion

A comparative analysis of the estimated parameters of training sessions showed a significant increase in SI, PIF, Average Power, and Average Flow in patients of Group 1. In patients of Group 2, we found only a tendency to be increased in these parameters, with the exception of Average Flow (Table 1).

Table 1.

IMT parameters in the studied groups before and after training sessions

Parameters	Group 1 (n=45)			Group 2 (n=44)			P_{1-2} after 8 weeks
	before	*P*	after 8 weeks	before	*P*	after 8 weeks	
SI, cmH_20	19.7±4.58	<0.05	28.83±6.21	18.80±5.11	>0.05	21.33±7.92	<0.05
PIF, l/sec	0.76±0.21	<0.05	1.53±0.32	0.78±0.26	>0.05	0.87±0.34	<0.05
Average pressure, cmH_20	6.99±2.31	>0.05	9.34±4.7	5.10±3.61	>0.05	6.59±2.58	>0.05
Average power, watt	0.31±0.11	<0.05	0.83±0.26	0.24±0.12	>0.05	0.36±0.21	<0.05
Average flow, l/ sec	0.48±0.12	<0.05	0.80±0.17	0.46±0.16	<0.05	0.78±0.26	>0.05
Average volume, l	0.71±0.28	>0.05	0.74±0.51	0.91±0.35	>0.05	1.10±0.62	>0.05

According to the estimated spirometric parameters, after 8 weeks of IMT, statistically significant differences between the groups were observed. In Group 1, FEV_1 increased from 44.1±3.3% to 48±2.7%, and FVC from 62±3.6% to 68±4.1% ($P<0.05$). Group 2 also showed an improvement in these parameters, but no statistically significant changes were found.

According to the severity of dyspnea at the baseline, in accordance with the mMRC questionnaire, there were no significant differences between the groups. Statistically significant differences were noted after 8 weeks from the beginning of IMT and were manifested in a significant decrease in mMRC scores in Group 1, and the lack of improvement in Group 2 (3.4±0.5 and 2.8±0.5, $P=0.01$; 3.5±0.6 and 3.4±0.2, $P=0.12$, respectively). Statistical analysis showed a close correlation between the SI and the severity of dyspnea on the mMRC scale (r=-0.52, $P<0.05$) in Group 1.

The data obtained do not contradict the results of a study by Villiot-Danger et al., in which 20 patients with morbid obesity (BMI=45±7 kg/m^2) took part.[19] Despite the fact that the authors did not show an increase in the strength of the respiratory muscles, a decrease in dyspnea was observed in COPD patients. In addition, IMT significantly improved the results of 6MWT and QL, while in the group without IMT changes were not observed. It was also suggested, that IMT could potentially prevent the early onset of respiratory muscle fatigue during exercise, and that in obese patients exercise tolerance may be increased due to a decrease in dyspnea, which, in turn, could be the basis of the improvement in QL observed in patients.

Thus, taking into account the results of our study, the IMT program was more effective in patients with COPD and obesity than in patients with normal body weight, especially in relation to such significant integral parameters as SI and PIF. A possible explanation for this may be that obese patients had worse muscle condition due to the peculiarities of their behavior with limited physical activity and lifestyle. By analogy with skeletal muscles, training and increasing the strength of the respiratory muscles is dose-dependent. Training with a constant ongoing load limits the load that a patient with COPD can reach, as fatigue develops quickly and rest is required.[20] IMT protocols, suggesting an interval approach with the inclusion of rest periods, during which there is a decrease in the severity of symptoms that appear in the exercise period, are more effective and allow optimizing the achievement of tolerance to large loads. This in turn contributes to the maximum increase in strength and endurance of the trained respiratory muscles.[21,22]

Thus, the results of our study indicate a positive effect of IMT in patients with COPD, and a greater effect in patients with obesity than in those with normal body weight. Clinically, an improvement in the IMT parameters was expressed in a decrease in dyspnea and an improvement in spirometric indicators. However, further studies are needed to finally assess the effect of various types and modes of respiratory muscle training in patients with COPD and obesity.

Competing Interests

The authors declare that they have no competing interests.

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