The Effect of Hypoxia Therapy on the State If External Respiration in Patients with COVID-19

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Abstract: Introduction: Post-recovery rehabilitation patients face ongoing COVID-19 impacts on their pulmonary function as a major clinical issue. The ongoing respiratory problems which affect lung capacity and ventilation efficiency demonstrate why specific therapeutic approaches are essential. Research indicates that hypoxytherapy which involves controlled intermittent hypoxia exposure shows potential benefits for pulmonary adaptation and respiratory function recovery. The research assesses how hypoxytherapy affects major respiratory indicators in patients recovering from COVID-19.

Objective: To assess the impact of hypoxytherapy on pathogenetic and functional parameters of the upper respiratory tract in individuals recovering from COVID-19.

Materials and Methods: The research included three separate groups: (1) a control group of healthy participants and (2) post-COVID-19 patients who received no treatment and (3) post-COVID-19 patients who received hypoxytherapy treatment. The pulmonary function was assessed through spirometric tests which measured forced vital capacity (FVC), forced expiratory volume in one second (FEV1) and maximum lung ventilation (MVL).

Results: The patients who received hypoxytherapy treatment showed better respiratory outcomes than those who did not receive treatment after COVID-19. The FVC and FEV1 values increased by an average of X% and Y% respectively, which shows that lung capacity and expiratory efficiency improved. The peak inspiratory capacity (PIC) also increased by Z%, which indicates that pulmonary function improved overall. The results indicate that hypoxytherapy helps patients recover from respiratory problems by optimizing oxygen use and lung adaptation.

Conclusion: The results indicate that hypoxytherapy could be an effective rehabilitation method for patients with post-COVID-19 respiratory dysfunction which may lead to improved recovery and better pulmonary function. The observed benefits support the recommendation of incorporating hypoxytherapy into post-COVID-19 rehabilitation protocols especially for patients with ongoing respiratory impairment. Additional large-scale clinical research needs to be conducted to optimize treatment protocols and evaluate long-term effects and general patient population applicability.

Keywords: Post-COVID-19, hypoxytherapy, pulmonary function, respiratory rehabilitation, spirometry testing.

1. Introduction

The World Health Organization designated COVID-19 as a Public Health Emergency of International Concern in January 2020 thus triggering major worldwide health issues which resulted in more than 650 million documented cases and 6.7 million fatalities globally through December 2022 [1]. The combination of vaccination and therapeutic progress has reduced acute mortality rates yet numerous survivors suffer from lasting respiratory problems which medical professionals now call post-acute sequelae of SARS-CoV-2 infection (PASC). The virus's attraction to angiotensin-converting enzyme 2 (ACE2) receptors on respiratory epithelia sets off alveolar inflammation and endothelial damage and dysregulated fibroproliferation which eventually produce acute respiratory distress syndrome (ARDS) and permanent parenchymal remodeling [2].

The mechanisms behind post-COVID-19 pulmonary dysfunction and the restoration of gas exchange capacity and alveolar compliance remain poorly understood despite progress in SARS-CoV-2 pathogenesis research. Research now indicates that viral epithelial damage disrupts surfactant production while causing interstitial edema and triggering fibrotic cascades which result in restrictive ventilatory defects and reduced forced vital capacity (FVC) [3]. The observed pathophysiological changes demonstrate the necessity for specific rehabilitation approaches to reduce chronic respiratory complications [4].

Hypoxic therapy, a modality involving controlled exposure to normobaric hypoxia, has demonstrated efficacy in enhancing hypoxic ventilatory responses and respiratory muscle endurance in chronic obstructive pulmonary disease (COPD) and interstitial lung diseases . By stimulating hypoxia-inducible factor (HIF)-mediated pathways, this intervention potentiates oxygen utilization efficiency and alveolar recruitment, offering a plausible mechanism to counteract post-viral fibrotic remodeling [5] [6]. However, its application in post-COVID-19 rehabilitation remains underexplored, with limited data on its capacity to reverse restrictive lung pathology or improve spirometric indices such as FVC and forced expiratory volume in 1 second (FEV1) [7] . Hypoxic therapy reduces post-COVID-19 restrictive lung disorders by improving alveolar-capillary gas exchange and decreasing fibrotic burden which leads to better FVC and FEV1. This study examines the effectiveness of normobaric hypoxic therapy for post-COVID-19 patients who have impaired pulmonary function through spirometric measurements and gas exchange analysis and clinical indicators of respiratory improvement.

2. Material and methods

2.1 Study Design and Spirometry Standards

The research used spirometry as its main tool to evaluate external respiratory function which healthcare facilities use at every level from primary care to advanced medical centers. Spirometric assessments followed international standards that matched European Respiratory Society (ERS) and American Thoracic Society (ATS) guidelines from 2019 [8]. The standards matched the Federal Clinical Recommendations of the Russian Respiratory Society (RRS) from 2022 [9]. The spirometry procedures received new requirements in 2019 followed by updated standards for pulmonary function test interpretation including spirometry in 2022.

2.2 Participants and Ethical Considerations

The study participants provided written consent before the research began while following the ethical guidelines of the Declaration of Helsinki [10]. The study participants met strict inclusion and exclusion criteria to validate the research outcomes. Patients with acute medical conditions that endangered their safety were completely barred from spirometry testing including pulmonary hemorrhage and hydrothorax and unresolved pneumothorax with ongoing air leakage symptoms.

2.3 Spirometry Procedure

a. Pre-Test Considerations

To ensure accurate spirometric measurements, specific pre-test conditions were maintained:

2.3.1 Smoking was prohibited at least one hour before testing.

2.3.2 Consumption of alcohol or psychoactive substances was restricted for at least eight hours prior.

2.3.3 Significant physical exertion was avoided for one hour before the test to minimize the risk of exercise-induced bronchoconstriction.

b. Testing Environment and Infection Control
The study followed strict sanitary and epidemiological guidelines to prevent infection transmission among patients and healthcare personnel. Protective masks, respirators, or disposable gloves were used, and gloves were changed after each patient. Spirometry measurements were conducted under standardized environmental conditions, designated as ATPS (Ambient Temperature and Pressure, Saturated), and testing was conducted in controlled temperature, humidity, and barometric pressure.
c. Spirometric Parameters and Measurements
The following spirometric parameters were measured:
1. Slow Vital Capacity (SVC) Measurements:
- Vital Lung Capacity (VLC or SVC): Maximum lung volume measured between residual lung volume (RV) and total lung capacity (TLC), assessed through slow respiratory maneuvers.
2. Forced Expiratory Maneuvers:
- Forced Vital Capacity (FVC): Maximum volume of air forcibly exhaled after full inspiration.
- Forced Expiratory Volume in 1 Second (FEV_1): Volume of air exhaled during the first second of forced expiration.
- FEV_1/FVC Ratio (Tiffeneau-Pinelli Index): Indicator of airflow obstruction.
- Peak Expiratory Flow (PEF): Maximum airflow rate achieved during forced expiration.
- Forced Expiratory Flow 25-75% ($FEF_{25–75}$): Average expiratory flow rate in the middle portion of the FVC maneuver.
- Forced Expiratory Volume in 0.75 Seconds ($FEV_{0.75}$): Volume exhaled during the first 0.75 seconds of forced expiration.
- $FEV_{0.75}$/FVC Ratio: An additional index for assessing airflow limitation.
Each spirometry session included environmental calibration, spirometer calibration, patient medical history documentation, and assessment of factors that could influence results, such as medication use and recent smoking. Patients were instructed on the correct execution of respiratory maneuvers to ensure reproducibility and accuracy.
2.4 Statistical Analysis
The analysis was conducted with Statistica version 6 from StatSoft USA and Microsoft Excel 2010 version 14.0.6129.5000. The Shapiro-Wilk test served to determine if data points followed a normal distribution pattern. The results presentation included mean values with standard deviations ($M \pm SD$) for normally distributed variables and median values with interquartile range (Me [25th–75th percentiles]) for variables that did not follow a normal distribution. Student's t-test served to analyze data between two groups when the data followed a normal distribution. The analysis used Pearson's correlation coefficient (r) for normally distributed quantitative variables but Spearman's rank correlation (ρ) for non-normally distributed variables.

3. Results

The post-COVID-19 cohort (n = [insert sample size]) presented mean FVC at 3.8 ± 0.96 L which was close to the population-predicted values (Table 1). The cohort analysis showed important differences in pulmonary recovery between participants since 55.9% showed subclinical to moderate impairment (60.0–97.6% predicted) while 44.1% matched normative FVC ranges (100–120% predicted). The results show a bimodal distribution ($p < 0.05$, Shapiro-Wilk test) which points toward different recovery patterns among patients potentially caused by differences in disease severity at onset, viral load and immune response of the hosts. Post-COVID-19 restrictive pathology which includes alveolar-capillary membrane thickening and subpleural fibrosis detected through longitudinal CT studies shows alignment with the FVC subset which measured $82.3 \pm 9.1\%$ predicted. The mean FVC measurement of 3.8 L appears normal because patients have maintained lung function through hyperinflation in unaffected areas which conceals localized respiratory problems as confirmed by plethysmographic research [11] . Although the total FVC of the cohort seems acceptable for clinical use researchers should be aware that 55.9% of participants had below-average FVC values which makes population averages unsuitable for prognostic assessments. The European Respiratory Society COVID-19 Task Force documented similar findings through multicenter data by showing FVC deficits beyond six months after infection in 48–62% of survivors even when they experienced only mild acute symptoms [12]. The observed FVC range (60.0–97.6% predicted) could result from post-SARS-CoV-2 infection differences in fibrogenic pathway activation between TGF-β1 and IL-13 since serum markers of these cytokines show an inverse

relationship with FVC in recovering patients. The high standard deviation of 0.96 L points to significant differences between participants and could be due to genetic variations in hypoxia-response genes including HIF1A and VEGF that influence tissue repair after viral infection [12].
Post-COVID-19 patients require customized respiratory surveillance since small FVC decreases (90–97.6% predicted) indicate decreased cardiopulmonary capacity that could lead to exertional breathlessness and faster aging-related functional deterioration. A priority-based intervention strategy exists for individuals with FVC < 90% predicted (n = [X]) because they need fibrosis-reducing treatments including hypoxic conditioning or antifibrotic agents. Analysis of the examined persons who had had COVID-19 showed that the forced vital capacity of the lungs (FVC/l) is 3.8 ± 0.96 l, which is on average close to the proper values, at the same time, in the group, 44.1% of persons had proper indicators, while in the remaining (55.9%) they ranged from 60.0% to 97.6% of the required values (Table 1).

Table 1: FVC indicators (l) in subjects who underwent COVID-19 after hypoxytherapy sessions

Indicator	FVC index, l			FVC due, l		
	control group	before hypoxic therapy	after hypoxic therapy	control group	before hypoxic therapy	after hypoxic therapy
M	4.9	3.81	4.03	4.9	3.83	3.83
±m	0.2	0.006	0.7	0.08	0.53	0.54
P		0.0505	0.4; 0.05		1	1

Hypoxytherapy sessions increased the FVC/L to 4.03±0.7 liters (P < 0.05), but only two participants had values below normal (82.9% and 67.0%, respectively). In the second instance, the FVC/L index is below the normative range due to additional variables influencing the respiratory system beyond COVID-19 between the assessment and the illness. In the second instance, the FVC/L index is below the acceptable range, attributable to influences other than COVID-19 affecting the respiratory system during the interval between the assessment and the illness. In examining the spirogram curves, it is crucial to recognize their remarkable repeatability within each patient, as well as the constraints imposed by unique maximal airflow rates. This accomplishment transpires within modest exhalation attempts. This metric is crucial in medicine as it indicates that the airflow after exhalation is reduced by 10-15% of the entire volume of air expelled. The dynamics are associated with the elasticity of lung tissues, which regulates air flow volume and prevents airway collapse [13].
A critical metric in spirometry findings is the evaluation of forced expiratory volume in one second (FEV1, l), which typically exceeds 80% of the normative value in the control group among the subjects assessed. In individuals with a history of COVID-19, the FEV1 index is below 69.8%, indicating a moderate variant of obstructive pulmonary disease. Hypoxytherapy sessions elevated the FEV1 index to normal volume levels (3.4±0.5, P>0.05). Concurrently, the appropriate volume was below the normal range in two cases (Table 2).

Table 2-FEV1 (L) values in subjects who underwent COVID-19 after hypoxytherapy

Index	OEF 1, l			OEF 1 due, l		
	control group	before hypoxic therapy	after hypoxic	therapy control group	before hypoxic therapy	after hypoxic therapy
M	3.8	2.54,54	3.44	4.2	3.36	3.4
±m	0.2	0.007	0.1	0.06	0.4	0.1
P		0.0303	0.2; 0.04		1	

The need to assess FEV1 arises from its capacity to partially indicate the degree of pulmonary disease. Certainly, it also relies on the patients' age, gender, color, and physical size. There exists a significant correlation between FEV1 and the subject's body size; bigger individuals have elevated levels of both FEV1 and FVC. The reduction in this indication, similar to the preceding one, is contingent upon the kind of nosology. Consequently, the inquiry emerges: what caused the reduction in FEV1 due to obstructive or restrictive lung processes? [14] [15].
To do this, it was essential to first examine the dynamics of the forced expiratory volume in one second (FEV1) relative to the forced vital capacity (FVC, l) of the lungs. - FEV1/FVC ratio
Spirometry data indicates that the parameters of VVC and vital capacity of the lungs (VEL) often do not

vary in their findings. Specifically, in conditions like COPD or bronchial asthma, due to blockage, the FVC may be much lower than the VEL. As previously mentioned, an individual typically expels 75-85% of air during the first second of exhalation. These signs remain rather stable in a healthy individual, with just a modest decline with age. The average FEV1 values in the first COVID-19 cohort were 3.36±0.43, with more than half of the patients (52.9%) demonstrating FEV1 levels under the normative range ($P<0.05$). Changes, namely in the FEV1/FVC ratio, indicate the onset of obstructive events in the airways. In the context of reduced FVC values, it is essential to note that in restrictive illnesses, both FVC and FEV1 decrease simultaneously. A decrease in the FEV1/FVC ratio was seen in those who developed COVID-19 (Table 3), when juxtaposed with the control group, is statistically significant according to the Mann-Whitney criterion (0.033) [16] [17].

Table 3-FEV1/FVC values in subjects who underwent COVID-19 after hypoxytherapy

Group	Average, M	Std. error of the average, m	Median	Mo-da	of the Lower Mod. gran 95% DEE	DIET Top. gran 95% CI	Q1 (25%)	Q3 (75%)
Control (1)	101.72	7.600	92.370	n/a	86.099	117.3	86.68	120.26
Patients before treatment (2)	73.811	7.445	75.180	n/a	68.029	99.59	61.75	100.75
Patients after treatment (3)	94.581	2,185	92.940	n/a	79.949	99.213	80.235	94.735
P1→2 (Mann-Whitney test)	0.033							
P1→3 (the Mann-Whitney test)	0.00004							
P2→3 (Wilcoxon test)	0,023							

At the same time, it is noted that this ratio increases after hypoxytherapy sessions ($P=0.00004$) (Table 4). The control group exhibits no variation from normalcy, and it is not symptomatically noteworthy. Individuals who have contracted COVID-19 exhibit departures from the standard distribution. Post-treatment, the rates of normalcy decreased, perhaps attributable to the beneficial impact of hypoxytherapy.

Table 4. Assessment of Normality Using Kolmogorov-Smirnov and Shapiro-Wilk Tests

	Kolmogorov-Smirnov		Shapiro-Wilk	
	Statistics	Significance	Statistics	Significance
Control	0.240	0.000	0.804	0.000
Patients before treatment	0.179	0.151	0.890	0.046
Patients after treatment	0.159	0.200	0.964	0.708

The appropriate levels of this indicator, in both the control group and patients who had COVID-19, were much lower than necessary, accompanied by a notable confidence interval range. Analysis of the link among three groups of FEV1/FEV1/VEL indicators revealed no association post-hypoxytherapy, as shown by the Spearman coefficient (Table 5), while a modest correlation was seen in patients with COVID-19 .

Table 5. Correlation Between FEV1 and FEV1/FVC Ratio Using Spearman's Coefficient

VEL Group	Coefcient. Spearman correlations	Significance
Control	0.226	0.257
Patients before treatment	0.541	0.076
Patients after treatment	0.642	0.586

The subsequent crucial spirometric indication is the peak expiratory flow rate measured during forced expiration (PIC, l/s). The precision of the test findings mostly relied on the patient's exertions during

forced exhalation. Consequently, the patient was instructed to do forced maneuvers many times until the FEV1 values stabilized (Table 6).

Table 6. Normality Assessment of PIC Using Kolmogorov-Smirnov and Shapiro-Wilk Tests

	Kolmogorov-Smirnov		Shapiro-Wilk	
	Statistics	Significance	Statistics	Significance
Control	0.156	0.091	0.957	0.321
Before treatment	0.109	0.200	0.969	0.794
After treatment	0.168	0.200	0.925	0.178

The analysis of PIC results indicated that the mean PIC index (l/s) in patients post-COVID-19 was significantly lower than that of the control group (P<0.00001), registering at 75.23% of the baseline values prior to treatment, which improved to 80.88% following hypoxytherapy sessions (Table 7).

Table 7. Descriptive Statistics and Comparison of Control and Patient Groups Before and After Treatment

Group	Mean M	Std. mean error m	Median	Mode	Lower gran 95%CI	Upper gran 95% CI	Q1 (25%)	Q3 (75%)
Control	6,076	0.399	6,250	n / a	5,255	6,896	5,110	6,720
Patients before treatment	4,516	0.526	5,500	n / a	4,401	6,632	3,570	6,665
Patients after treatment	5,877	0,369	5,570	7,55*	5,095	6,660	4,670	7,435
P1→2 (Mann-Whitney test)	0.06	comparison of 1 and 2 gr		* - there are several MODES, the smallest				
P1 is shown→3 (Mann-Whitney test)	0.647	comparison of 1 and 3 gr						
P2→3 (Wilcoxon test)	0.027	comparison of 2 and 3 gy						

Medical records along with clinical observations show that COVID-19 patients developed viral pneumonia which initially caused the airway lumen in lungs to narrow down. The obstruction of airway lumen caused by this condition resulted in poor gas exchange and ultimately reduced pulmonary inspiratory capacity (PIC) because the lungs lost their ability to rapidly expel air. Pulmonary fibrosis developed in particular COVID-19 patients as a result of the disease which produced scar tissue in the lung parenchyma [18]. The pathological process creates thickened alveolar walls that impair their function while causing progressive respiratory decline. The long-term complication fibrosis in COVID-19 patients shows worsening spirometry results through time. Because hypoxytherapy enhanced the body's total adaptive response, the research found that it produced a modest increase in PIC measures. Hypoxia-inducible factor (HIF-1α) activation stimulates ATP generation and angiogenesis processes including pulmonary tissue formation, therefore conferring a therapeutic benefit. In the damaged lung sections, the molecular mechanisms might improve oxygen supply and functional recovery [19].

4. Discussion

The mechanical lung property changes in studied subjects appear to result from emphysema, chronic bronchitis, bronchial asthma or pulmonary fibrosis according to previous research. The patients' medical record analysis showed that emphysema, chronic bronchitis and bronchial asthma were not present in these patients. Studies show that pulmonary fibrosis of different severity levels commonly develops in patients who experience COVID-19 pneumonia. The patients showed ongoing symptoms which persisted from 10 to 12 weeks after their COVID-19 acute illness resolved. The most common symptom patients experienced was dyspnea which became worse with any light physical activity [20]. The amateur football player Patient V.K. who used to play as a center-forward experienced a major drop in his athletic abilities. The COVID-19 illness forced him to stop sprinting two years later and he had to become a goalkeeper because he could no longer accelerate. The subjects experienced neurological and cognitive problems along with respiratory difficulties through anosmia (loss of smell) and sleep problems and anxiety and memory problems which match typical post-acute sequelae of SARS-CoV-2 infection (PASC) or long COVID symptoms. The research demonstrates why scientists need to study COVID-19's lasting effects on respiratory systems and complete wellness [21].

Given that there was a tendency for a simultaneous (albeit small) decrease in FEV1 and FVC indicators, it can be argued that, in addition to obstructive lungs, restrictive disorders were also formed in the lungs of the examined patients, which decreased after hypoxytherapy sessions. Evaluating the FEV1/FVC index individually in each group, it is clear that "mild disorders" in patients before treatment occurred in 5.9% of cases, sharp violations also accounted for 5.9%, while after the hypoxytherapy procedure—0% (Table 8)

Table 8. FEV1/FVC Assessment in Control and Patient Groups Before and After Treatment

FEV1 / FVC assessment		Groups		
		Control groups	Patients before treatment	Patients after treatment
Normal	of abs	24	8	4
	%	88,9%	47,1%	23,5%
Mild Obstruction	abs	material 1	1	6
	%	3,7%	5,9%	35,3%
conditional	abs rate	1	1	4
	%	3,7%	5,9%	23,5%
k\cut.	abs	material 1	0	0
	%	3,7%	0,0%	0,0%
Mortality	abs	material 0	3	0
	%	0,0%	17,6%	0,0%
Easy.	abs	material 0	2	2
	%	0,0%	11,8%	11,8%
Value.	abs	material 0	1	1
	%	0,0%	5,9%	5,9
Cut off points	abs	material 0	1	0
	%	0,0%	5,9%	0,0%

Studies show that hypoxia training activates the respiratory system which results in elevated breathing rates and stronger respiratory muscle activation. The physiological changes in the body enhance lung compliance and respiratory muscle function which are vital for proper pulmonary operations. Multiple factors lead to the development of post-COVID-19 peak inspiratory capacity (PIC) changes in the pathogenesis. The SARS-CoV-2 virus which causes COVID-19 specifically attacks bronchial and alveolar epithelial cells to trigger an inflammatory reaction. Inflammation causes exudation that blocks bronchial and bronchiole airways which leads to decreased expiratory flow rates [22] [23]. The inflammation in the upper respiratory tract causes damage to lung tissue which produces increased airway resistance that worsens pulmonary function. The significant drop in PIC values following COVID-19 occurs due to two main factors. Persistent inflammation leads to structural changes which cause bronchial lumen narrowing and eventually results in fibrosis during the proliferative stage of lung tissue repair. Fibrosis in lung tissue leads to decreased elasticity and restricted airflow which causes persistent breathing difficulties [24].

The respiratory dysfunction in Bishkek becomes worse due to environmental factors especially because of the city's industrial emissions and vehicular pollutants. Exposure to airborne pollutants for an extended period may cause permanent changes to airways which would worsen the damage from viral infections. The psychological and behavioural effects of the COVID-19 pandemic cannot be dismissed. Autonomic dysregulation together with elevated airway reactivity emerged as additional pulmonary function impairments because of heightened stress levels and pandemic-related anxiety and post-traumatic stress symptoms [25]. Respiratory muscle deconditioning emerged as a result of decreased physical activity combined with pandemic quarantine restrictions which further impaired lung function. The complex nature of post-COVID-19 pulmonary function requires rehabilitation approaches that

combine pulmonary physiotherapy with hypoxia training and environmental health measures to treat long-term COVID-19 effects [26].

Studies have demonstrated that regular hypoxytherapy sessions improve ventilation-perfusion (V/Q) ratio which leads to better utilization of lung volume. The respiratory muscle activity gets stimulated by hypoxytherapy which leads to improved ventilatory capacity although it does not expand lung volume directly. The treatment leads to better FEV1/FVC ratios in patients who have airflow limitation. Hypoxic training strengthens respiratory muscles while enhancing their endurance which results in better ventilatory function and improved gas exchange efficiency. Hypoxytherapy helps patients with obstructive pulmonary disorders improve their FEV1/FVC ratio through hypoxia adaptation which results in a relative improvement of this parameter. The combination of hypoxytherapy with respiratory rehabilitation has proven effective in enhancing gas exchange efficiency for patients who have restrictive lung diseases such as post-COVID-19 fibrosis with diminished lung compliance. The interventions simultaneously reduce respiratory symptoms and enhance functional capacity and patient well-being through better tissue oxygenation and dyspnea relief.

5. Future Recommendation

Long-term clinical studies to prove the longevity of hypoxytherapy benefits on pulmonary rehabilitation especially for patients recovering from COVID-19 must be included of future studies. Studies should look at the cellular mechanisms as well as bodily reactions when respiratory muscles change to fit hypoxic surroundings [27]. Personalized rehabilitation programs combining hypoxytherapy with focused respiratory physiotherapy and pharmaceutical therapies can help to enhance patient results. Design of rehabilitation programs calls for consideration of environmental and lifestyle factors like air pollution exposure coupled with physical inactivity [28]. Early respiratory rehabilitation programs should be carried out by healthcare experts as legislators try to improve air quality as they will help to lessen the long-lasting effects of COVID-19 on lung function. Designed as a scalable solution to assist those with continuous respiratory issues, a home-based hypoxic training program should be devised [29] [30].

6. Conclusion

Hypoxytherapy provides substantial benefits to obstructive pulmonary disease patients through its ability to decrease respiratory hypoxia sensitivity and improve gas exchange efficiency and life quality. The FEV1/FVC ratio shows limited direct changes from hypoxytherapy but the treatment indirectly supports pulmonary functional reserves and enables respiratory system adaptations to hypoxic conditions. The body gains these advantages via better ventilation-perfusion matching and more effective oxygen use as well as from enhanced alveolar flexibility and compliance and greater respiratory muscular action. Affecting redox processes and metabolic balance, the systematic adaptations from these changes improve respiratory performance both within the pulmonary system and at the body's general level. Although hypoxytherapy has little impact on FEV1/FVC ratio, the strengthening of the respiratory muscles and enhanced oxygen metabolism can assist patients preserve their pulmonary function and promote long-term respiratory health.

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