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REHABILITATION IN PATIENTS WITH LUNG DISEASES IN CONDITIONS OF PANDEMIC, CAUSED BY CORONAVIRUS SARS-COV-2

ABSTRACT
of a dissertation for awarding of a scientific and educational degree "Doctor"

Scientific specialty:
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The dissertation contains 187 standard pages and is illustrated with 32 tables, 23 figures, and contains 6 appendices.
Quoted are 362 literary sources, of which 7 in Cyrillic and 353 in Latin.

The number and the numbering of the tables and the figures in the abstract does not correspond to those in the dissertation.

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The materials on the defense are on disposition in the Educational department at the MU-Varna and are published on the website of the MU-Varna.

CONTENTS

USED ABBREVIATIONS

RR	Respiratory rehabilitation
ECG	Electrocardiography
CT	Computed tomography
COPD	Chronic obstructive pulmonary disease
WHO	World Health Organization
ATS	American thoracic society
ERS	European respiratory society
SARSr-CoV-2	Severe acute respiratory syndrome related coronavirus-2
COVID- 19	Coronavirus Disease 2019
RT-PCR	Reverse Transcription Polymerase Chain Reaction
ASVT	Active Cycle of Breathing Techniques
EQ-5D-3L	Questionnaire for the health condition (EuroQol-5D)
HADS	Hospital Anxiety and Depression Scale
CRP	C-reactive protein
KGA	Blood - gas analysis
ASAT	Aspartate aminotransferase
ALAT	Alanine aminotransferase
GGT	Gamma-glutamyl transferase
30SCT	30 Second Sit to Stand Test

1. INTRODUCTION

In 2020, humanity faced the challenge of the pandemic resulting from the spreading of the new beta-coronavirus SARS-CoV-2. COVID-19 is the disease which is caused by this virus, called coronavirus on heavy sharp respiratory syndrome (Severe Adult Respiratory Syndrome Coronavirus 2 (SARS-CoV-2); [Zimmer C, 2021]. There have been data on first cases of the disease in the city of Wuhan, Hubei, China back in December 2019. The World Health Organization (WHO) declared a pandemic on March 11, 2020 [World Health Organization 12 March, 2020]. After data of the WHO by September 2022 the coronavirus infection caused the death of over 6 500 000 people worldwide and of over 37,000 people in Bulgaria. https://www.who.int/. In addition, patients with COVID-19 suffer from post-COVID-19 syndrome, associated with the presence of symptoms after the acute infection has subsided. In times of the SARS-CoV-2 coronavirus, physical therapists are standing up in front of new challenges in the field of their own activity. General statements cannot be made about the "typical" course of the disease in Covid-19, because the course is non-specific and varies. The spectrum of the disease varies from asymptomatic progressing to severe pneumonia with acute respiratory distress syndrome and death [Konietzko B, 2020].

COVID-19 affects both the physical and the mental condition of patients. Approximately 14% of patients with COVID-19 require hospitalization, and extremely severe cases require intensive care. Such patients may develop a range of dysfunctions, like damages on the pulmonary function, neurological impairments, reduced physically capacity, muscular weakness and psychological and cognitive disabilities [Tian S et al., 2020]. The studies before the pandemic of COVID-19 show that patients with severe lung damage may still have significant physical impairments, such as problems with the balance and muscular weakness even years after the hospital discharge, which, in turn, can increase the risk of fall [McCarthy B et al., 2015]. Crossed study on Baricich and co. found that 3-6 months after discharge, 32% of patients with COVID-19 still had impaired physical activity [Baricich A, et al., 2020]. These findings emphasize the importance of rehabilitation, even after patients are discharged from hospital.

Respiratory rehabilitation (RR) is a multidisciplinary and comprehensive approach that aims to improve the self-control ability of patients suffering from respiratory diseases [Chumpangern W, Khotsopa T, 2022]. RR was originally developed for the control of chronic obstructive pulmonary disease (COPD), and today it is included in the main treatment of patients with COVID-19. In the years since the onset of the pandemic significant number of studies and guidelines summarize the role of physiotherapy in the rehabilitation on patients with COVID-19 [Sheehy LM, 2020; Rivera-Lillo G, 2020]. Respiratory rehabilitation provides minimal risk due to which it can safely be applied in hospital settings for acute infection and a long-term approach to reducing symptoms after COVID-19.

Because of the urgent need for guidelines on how to treat these patients, they are mostly based on expert opinion or evidence of patients with other pulmonary diseases, a not on evidence. Numerous clinical trials have already been conducted and published for rehabilitation of patients with COVID-19, which emphasizes the need to update the current guidelines.

2. PURPOSE And TASKS

The aim of the present study is to evaluate the effectiveness of respiratory rehabilitation in hospitalized patients with COVID-19 pneumonia and respiratory failure in terms of clinical course, impact on quality of life and psycho-emotional status.

Tasks :

1. To determine the changes in clinical symptoms in patients with COVID-19 pneumonia after conducted respiratory rehabilitation
2. To determine the changes in the physiological indicators and the indicators from the blood gas analysis after respiratory rehabilitation
3. To determine the changes that occur in terms of physical activity
4. To evaluate the changes in quality of life in the studied groups of patients
5. To evaluate the changes in the psycho-emotional state in the studied groups of patients
6. To offer a rehabilitation program for patients with COVID-19 pneumonia in a hospital setting

3. PATIENTS And METHODS

Accomplished is a prospective research, which includes 124 sick with radiographically and computed tomography confirmed bilateral pneumonia and respiratory failure caused by Sars-Cov-2 virus, admitted for treatment in the Covid ward - Thoracic surgery at UMPHAT "St. Marina" - Varna for the period from January 2021 to January 2022. 62 of the patients are included in a group, which, along with the standard treatment conducts respiratory rehabilitation – studied group, 62 patients received standard treatment, without respiratory rehabilitation – control group.

Including criteria:

- patients aged over 18 years with radiologically proven bilateral pneumonia, positive for Sars-Cov-2 viral infection, proven by rapid antigen test or PCR test;
- patients, having signed informed consent and stated willingness to participate in the study.

Excluding criteria:

- patients aged under 18 y.;
- patients no having consented participation in the survey;
- patients, not having signed an informed consent;
- patients with severe accompanying diseases, hemodynamically unstable;
- patients on invasive or non-invasive pulmonary ventilation.

Methods

The following tests were performed for the patients:

- physical examination;
- ECG;
- measurement of arterial pressure;
- measurement of heart rate;
- non-invasive measurement of saturation of oxygen using a pulse oximeter;

- Peripheral blood count;
- Blood gas analysis (BGA);
- Biochemical analysis studies (CRP, ferritin, fibrinogen, ASAT, ALAT, GGT, indicators of coagulation);
- Survey study: filling of a questionnaire card with demographic data: gender, age, height, weight, smoking, education, history of accompanying diseases;
- Test for physically capacity – 30SCT;
- Assessment of the degree of breath shortness upon physical exertion with the modified Borg scale;
- Completion of questionnaires concerning quality of life and psycho-emotional state: EQ 5D-3L, HADS.

3.1. Survey study

The patient questionnaire was completed by members of the research team. In one part of it, demographic data on the researched persons were filled in during admission: gender, age, height, weight, smoking, education, history of accompanying diseases. In the other part of the questionnaire, the results of the tests carried out on the first, third and on the day of discharge were entered.

3.2. Physical capacity assessment test – 30SCT

The study used the 30-second sit-to-stand test (30STS) as one of the prospective tools to assess submaximal the physical capacity in COVID-19 patients. Participants were instructed to begin the test sitting on a 43 cm high chair or on the edge of a bed with their arms crossed in front of their chest. The height of the bed was adjusted to the height of each participant's knees. They were then asked to stand up as many times as they could for 30 s. The number of uprights was recorded in each patient questionnaire [Núñez Cortés R, et al., 2022]. A lower score on the 30STS indicates reduced physical capacity, reduced muscle strength for the lower limb, suggesting poor mobilization. The 30 STS result was classified according to the stratification in healthy adult population [Centers for Disease Control and Prevention

(CDC). Assessment 30-second chair stand 2017. Centers for Disease Control and Prevention (CDC). Available from: https://www.cdc.gov/steadi/pdf/STEADI-Assessment-30Sec508.pdf]. SaO2 and heart rate measurements were performed before and after 30STS to ensure patient safety. The test was discontinued if a participant had a decline of SaO2 < 90% or with ≥ 2% difference compared to the previous measurement during the test [Rikli, Jones, 1999]. Patients with increased heart rate of > 150 beats/min were not allowed to take part in the study. The test was performed three times: on the day of admission, on the third day of hospitalization and on the day of discharge. On the day of admission 21 patients did not fulfil the test due to fear of deterioration, and on the day at discharge theirf number was 12.

3.3. Assessment of the degree of breath shortness upon physical exertion with the modified Borg scale

The Borg scale is used to assess the degree of dyspnea during physical exertion [Borg G, 1982]. The modified Borg scale represents a ten-point scale (0 – 10 points) for subjective determining of the level of shortness of breath during physical exertion. The higher number of points means stronger a feeling breath shortness (see Appendix 3). A lot authors recommend the Borg scale for assessment of the effect of conducting kinesitherapeutic procedures 16, 17, 20. [Foglio K, Bianchi L, Bruletti G et al., 1999], [Griffiths T et al., 2000], [Kendrick K et al., 2000]. We used the Borg scale in this study as a method to assess the manifestations of dyspnea during performance of the 30STS test for determining physical capacity.

3.4. Methods for assessment of the quality of life and the psycho-emotional condition: questionnaires EQ 5-D-3L, HADS

3.4.1. Questionnaire for the health status EQ 5-D- 3L

To assess the health status of the study participants we used the Bulgarian version of the EQ 5-D-3L test. The 3-level version of the EQ-5D (EQ-5D-3L) was introduced in 1990 by the EuroQol Group. EQ-5D-3L essentially consists of 2 pages: descriptive part EQ-5D and EQ visual analog scale (EQ VAS).

The descriptive part of the EQ-5D-3L test includes the following five "areas" [Vankova, 2013] related to "mobility", "self-care", "usual activities", "pain/discomfort" and "anxiety / depression'. Each area has 3 levels: no problems, some problems and extreme problems. The patient is asked to indicate his/her health condition by putting a bookmark in the cell next to the most appropriate statement in each of the five measurements. This answer leads to a single digit number, which expresses the level selected for this measurement. Numbers for the five dimensions can be combined in a 5-digit number, which describes the health status of the patient.

The visual-analog scale (EQ VAS) use reports self-assessment of patient health in a vertical visual analog scale, where endpoints are labeled as “Best health status, which you can imagine" and “The worst health condition you can imagine”. VAS can be used as a quantitative measure of the health score that reflects a patient's own judgment.

3.4.2. HADS

SARS-CoV-2 infection and the COVID-19 disease are often associated with psychoemotional disturbances. As a tool for assessing the psycho-emotional state of the studied participants, we used the Hospital Anxiety and Depression Scale (HADS). HADS [Snaith & Zigmond, 1994] is a self-evaluation questionnaire, which is used to screen anxiety and depression symptoms (in 2 subscales). Patients had the opportunity to choose one answer from four offered for every question. The researched persons received instructions not to think too long about their answers and to answer spontaneously. The congregation of the points from the questions for anxiety ("A") and depression ("D") was compared with a scale and defined in four degrees as normal, mild, moderate and severe disturbance of the psycho-emotional state. The test was completed threefold: on the day of admission, on the third day of hospital stay and on the day of discharge.

3.4.3. Methods of physiotherapy treatment

Participants were given a set of performance-related instructions on respiratory exercises and positions in the bed and were requested to perform them during hospitalization. Patients received an instruction booklet adapted from the Rehabilitation Program of the Clinic for Rehabilitation Medicine, Solothurn Hospital, Switzerland. The researched persons were instructed by the members of the team for conducting the diagnostic tests and they had

opportunity to contact by phone for questions, concerning their health condition. The patients were encouraged to report for any kind of complaints during exercise, such as dizziness, dyspnea and lack of oxygen.

The respiratory rehabilitation (RR) plan included position changes of the body, which optimize the ventilation and improve gas exchange, passing through lateral, half bed position and prone position. The RR plan also included active cycle breathing techniques, breath shortness control, breath techniques for slow exhalation for patients who don’t develop desaturation, techniques, which decrease respiratory rate.

Each phase of RR was performed under the supervision of the medical team with the goal of gradually achieving the level of independence during exercise.

Based on the conducted studies, we implemented the following kinesitherapy program for the patients included in the study.

Positions and respiratory exercises

The patients were advised to change the positions of their body every two hours throughout the day passing through bed, semi-bed and lateral bed position. The change of position of a patient decreases the development of decubitus ulcers and may reduce the degree of dyspnea.

(P1) starting position: supine with head on the pillow at an angle of 45 degrees to the surface of the bed/side lying with elevation of the upper part of the body, control of breathing (ACBT); purpose: facilitating breathing;

(P2) starting position: raising the upper body at an angle of 45 degrees, placing pillows under the armpits on both sides, placing a pillow under the knees, breathing control (ACBT); purpose: facilitating breathing by reducing the load on the upper limbs;

(P3) starting position: position at 135 degrees in an incomplete prone position, with the body turned slightly to the side, a pillow is placed under the head and a blanket in front of the abdomen, calm and even inhalation/exhalation. Duration: individual tolerability, up to 2 hours; purpose: better ventilation of the posterior departments of the lungs;

(P4) starting position: prone position, with a small pillow under the abdomen/pelvis and hands under the forehead, easy and even inhalation/exhalation. Duration: individual tolerability, up to 2 hours; purpose: better ventilation of the posterior lung departments;

(P5) starting position: knee-elbow position with the head supported on

the hands or the mattress of the bed, calm and even inhalation/exhalation; aim: better ventilation of the posterior lung departments;

(P6) starting position: optionally, sitting on the edge of the bed/or sitting on a chair/or sitting on a chair with stepping over and carrying the upper part of the body, calm and even inhalation/exhalation; purpose: better ventilation of the dorsal lung departments, facilitating breathing;

(P7) starting position: upright standing with support of the hands on the knees /or with hands, leaning back against the wall, easy and even inhalation/exhalation; purpose: to facilitate breathing by relieving the burden on the shoulder girdle.

Breathing with pursed lips: starting position: sitting, shoulder and neck muscles are relaxed. The patient inhales slowly through the nose for two seconds while holding mouth shut, but breathing normally. Individuals are advised that it may be helpful to count by themselves: breath in, one, two. After this they must "squeeze" their lips as if whistling or gently blowing out a candle flame, then exhaling slowly through pursed lips while counting to four. "It may be helpful to count: exhale, one, two, three, four". The exercise is performed with progressive increase of the duration, from 1 to 5 minutes, depending on fatigue that may occur.

Purpose: Facilitates breathing by helping to keep the airways open using slight resistance to breathing through pursed lips upon exhalation.

Active cycle of respiratory techniques:

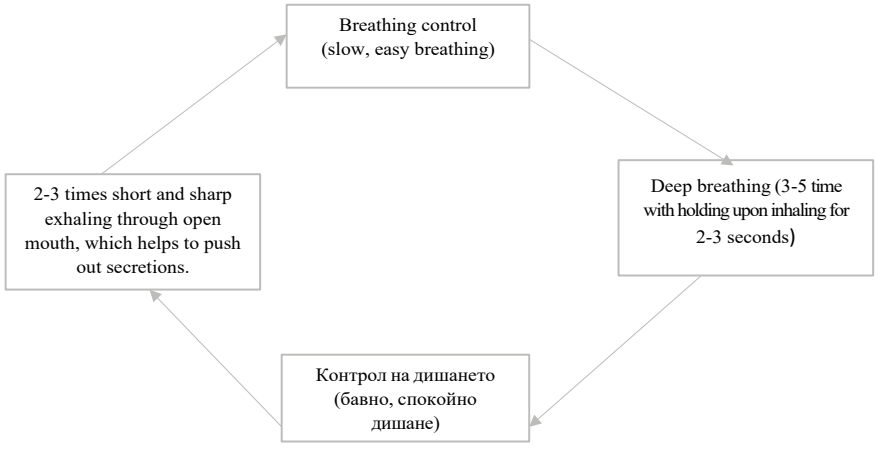


Fig. 1. Active cycle of respiratory techniques, adapted by: © East Sussex Healthcare NHS Trust - www.esht.nhs.uk

The patients were instructed to change often the position in the bed and to conduct the active cycle of respiratory techniques 1–2 times a day for up to 10 minutes, according to individual tolerance.

During the implementation of the rehabilitation program the researched persons were monitored by a team, composed of doctors and nurses. During hospitalization, all patients involved in the study received similar medical treatment for COVID-19 according to currently available admission guidelines.

All patients from the research were advised to continue to perform the adopted rehabilitation program at home and to gradually enrich it with the introduction of new exercises to restore the physical capacity to that before the onset of the disease. The patients were stimulated for adequately tracking, with recommendation to contact the attending physicians in a period of two weeks and a month after discharge from the ward in order to assess the need for additional treatment and rehabilitative events, connected with persistent symptoms.

Criteria for suspension of the rehabilitation program are: reduction of SpO2 with >4% from the output level, increase of respiratory frequency > 40 breaths/min, values on the arterial pressure of < 90/60 or > 180/90 mmHg or > 20% change in comparison with base level, heart rate < 40 or > 120 beats/min, new arrhythmia and myocardial ischemia, body temperature > 38.0°C, worsening shortness of breath or unbearable fatigue [Kurtaiş Aytür Y, et al., 2021].

3.4.4. Statistical methods

Analysis of quantitative variables

The data are summarized by descriptive statistics with metrics of central tendency (mean, median) and variation (standard deviation, interquartile scope, swing, minimal and maximum values).

The normality of the data verified through tests on Shapiro-Wilk and Kolmogorov–Smirnov.

In data analysis and hypothesis testing, the following were applied: interval estimation with 95% confidence interval, tests for differences between groups depending on the type of data distribution (independent sample t-test/ Mann–Whitney U test for independent groups, MANOVA/Friedman's ANOVA for analysis on repetitive research (three and more it dependent samples) paired t-test / Wilcoxon signed-rank test for analysis before and after the application of the rehabilitation program). Post Hoc comparisons are made Pairwise Comparisons Durbin-Conover in non-parametric and Bonferroni in parametric methods.

Adopted level of significance $\alpha = 0.05$. The observed differences between the groups of patients were considered credible in the cases when the calculated probability $p < \alpha$.

Analysis of the quality variables

Qualitative characteristics of the patients included in the research, presented characteristics regarding accompanying diseases, the severity of the pneumonia, the results of self-assessment of patients, measured through EQ-5D-3L. The calculations are presented in tables and patient frequencies in number and % were analyzed. To compare groups of patients a test is used for comparability on the groups – the test of Pearson, Fisher's exact test McNemar test, and for them the level of significance is $\alpha = 0.05$. Spearman's rank correlation coefficient (r) was used to examine correlations.

Graphic presentation

Descriptive statistics are presented with boxplot type graphs (for visualization of median and Q1 and Q3), frequency data are presented in appropriate column and bar diagrams to represent the distribution and structure of the studied phenomena.

Statistical software

All statistical analyses were performed with the help of the software program SPSS, version 25 (IBM, Armonk, USA), Jamovi version 2.4.11, Excel 2010.

4. RESULTS

4.1. Demographic data of the examined persons

For the purpose of the study, 124 patients were examined, 62 from work and 62 from control group, at an average age 56.3 ± 12.8 years and 59.1 ± 14.4 years respectively (t = 1.12, p = 0.177). The distribution by gender in both groups is even: in the control group, an equal number of men and women, in the work group there are more women, without statistical significance. Demographic data of the patients from both groups are indicated in Table 1.

Table 1. Demographic data of the patients participating in the research

Characteristic-tics	Control group (N = 62)		Working group (N = 62)	Stat. test	P
age, year	Mean (SD)	59.06 (14.42)	56.32 (12.77)	t test	0.177
	Me (Q1;Q3)	60 (48;70)	58 (47;65)		
	Min	22.00	27.00		
	Max	84.00	85.00		
Gender, n (%)	Male	31 (50)	27 (43.5)	P(χ2)	0.472
	Female, n (%)	31 (50)	35 (56.5)		

Table 2. Distribution of patients by accompanying diseases

Characteristics	Control group (N = 62)		Work group (N = 62)	Stat. test	P
Accompanying diseases, n (%)	Hypertension	36 (58.06)	33 (53.2)	P(χ2)	0.588
	Other CV diseases	13 (20.97)	8 (12.9)	P(χ2)	0.231
	Endocr. And metabol. diseases	16 (25.81)	7 (11.3)	P(χ2)	0.065
	Other diseases	10 (16.13)	12 (19.4)	P(χ2)	0.638

Predominant accompanying disease for both groups is arterial hypertension. Arterial hypertension was diagnosed in 33 (53.2%) cases in the group of patients undergoing respiratory rehabilitation and in 36 (58.1%) patients in the control group, without a statistically significant difference.

Patients with other CVDs in the working group were 8 (12.9 %) and 7 patients (11.3 %) had proven accompanying endocrine and metabolic diseases (Figure 4).

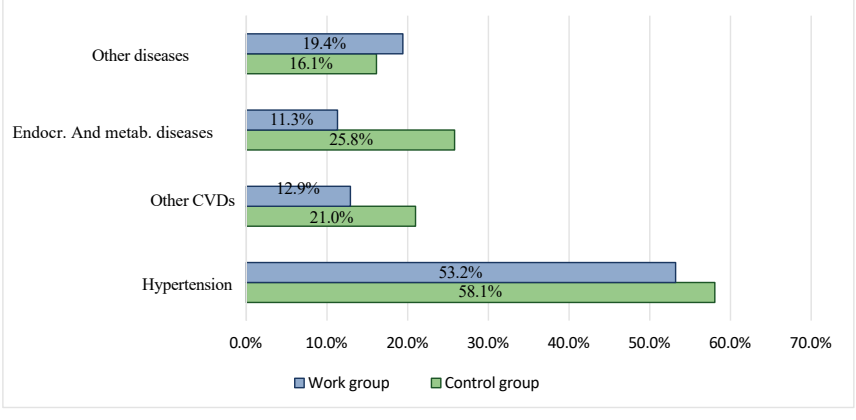


Figure 2. Distribution of the participants in the survey by accompanying diseases

In each of the groups, the survey participants were divided by age into two subgroups: up to 60 years (inclusive) and from 61 years on (Figure 3).

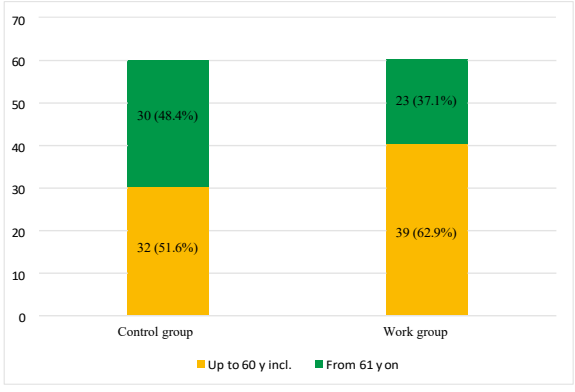


Figure 3. Distribution of participants in the survey by age groups

Demographics characteristics of patients in the subgroups by age are listed in Table 3.

Table 3 . Demographic characteristics of survey participants by age subgroup

Characteristics		Up to 60 y(incl.) Contr. group (N = 62)	Up to 60 y(incl.) Work group (N = 62)	Stat. test	P	From 61 y. on Contr. group (N = 62)	From 61 y. on Work group (N = 62)	Stat. test	P
Gender, n (%)	Male	19 (59.4%)	18 (46.2%)	χ2	0.267	12 (40.0%)	9 (39.1%)	P(χ2)	0.949
	Female	13 (40.6%)	21 (53.8%)			18 (60.0%)	14 (60.9%)		
Age in men, years	Mean (SD)	47.05 (7.65)	50.5 (7.23)	t test	0.168	70.3 (6.23)	65.56 (4.8)	t test	0.07
	Me (Q1;Q3)	46 (42;53)	49.5 (45;58)			68 (66.5;75)	65 (62;65)		
	Min	30.00	37.00			61.00	61.00		
	Max	60.00	60.00			82.00	74.00		
Age in women, years	Mean (SD)	47.7 (10.74)	47.4 (10.5)	U test	0.972	72.39 (6.44)	71.29 (6.1)	t test	0.626
	Me (Q1;Q3)	50 (44;50)	52.5 (39;55)			73.5 (68;77)	71 (67;76)		
	Min	22.00	27.00			61.00	63.00		
	Max	59.00	60.00			84.00	85.00		

In the subgroup up to 60 years of age in the group with DR 21 (53.80%) of the participants were women and 18 (46.20%) were men, in the control group 13 (40.60%) of the subjects were women and 19 (59, 40%) are men. In the group of patients with DR, subgroup from 61 Mr. 14 (60.90%) are women and 9 (39.10%) are men . IN subgroup of 61. 18 (60%) were female and 12 (40%) were male (Figure 4).

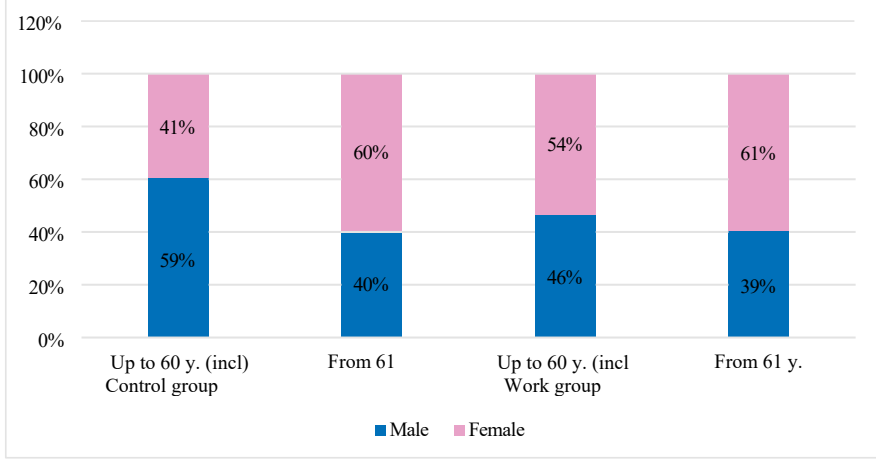


Figure 4. Distribution of the patients by gender in age groups , *%*

The average age for the men in the subgroup up to 60 y. from the group with RR is 50.5 (7.23) years, in the control room the group the men are younger – 47.05 (7.65) years, in the women from the same aged subgroups similar trend is observed: the median average age is 52.5 (39;55) in the group with RR and 50 (44; 50) in the control group (Figure 5). The distribution by gender shows that no statistically significant age difference is found in women and men up to 60 years in the control and work groups, that is, the groups are homogeneous.

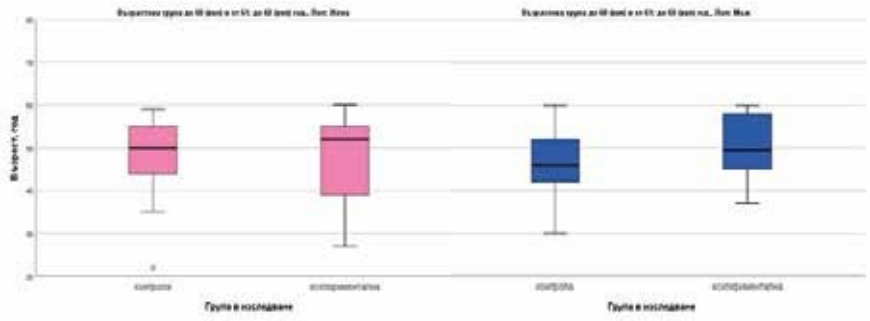


Figure 5. Distribution of the men and women by age up to 60 y. in the control and surveyed group

In the age subgroups from 61 y. on, men were older in the control group – 68 (66.5; 75) years is the average median age and 65 (62; 65) in the group with RR. Bigger variation is observed in age in men in the control group, as well as a statistically significant difference between the two groups. For women, age is more uniform: 72.39 (6.44) for the control group and 71.29 (6.1) for the work group, without statistical significance for the age difference (Figure 6).

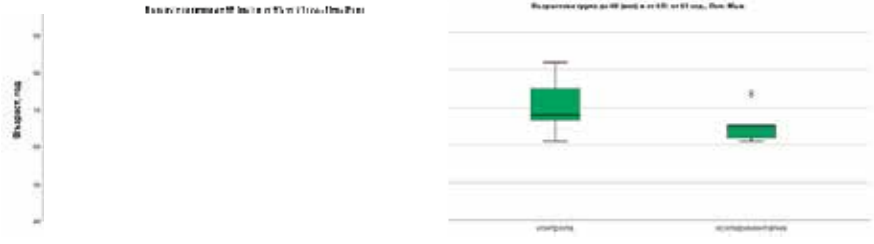


Figure 6. Distribution of the men and women by age in a subgroup > 61 y. from the control and the surveyed group

Regarding accompanying diseases, a relatively even distribution is observed in the same age subgroups, with biggest share of hypertension (Table 4). Exception are the endocrine and metabolic diseases, as more often are registered in the control group in patients over 61 year – 13 (43.3%) of the whole

subgroup, while in the experimental there are 3 (13%) patients with similar diseases.

Table 4. Accompanying diseases of the participants in the survey compared by age subgroups

Accompanying diseases, n (%)	Up to 60 . (incl)				From 61 y. on			
	Control group (N = 32)	Work group (N = 39)	Stat. test	P	Control group (N = 30)	Work group (N = 23)	Stat. test	P
No diseases	12 (37.5%)	17 (43.6%)			4 (13.3%)	2 (8.7%)		
Hypertension	15 (46.9%)	14 (35.9%)	$\chi 2$	0.349	21 (70%)	19 (82.6%)	$\chi 2$	0.290
Other CVDs	3 (9.4%)	3 (7.7%)	Fisher's ET	1.000	10 (33.3%)	5 (21.7%)	Fisher's ET	0.539
Endocr. And metab. dis.	3 (9.4%)	4 (10.3%)	Fisher's ET	1.000	13 (43.3%)	3 (13%)	Fisher's ET	0.033
Other diseas.	5 (15.6%)	6 (15.4%)	Fisher's ET	1.000	5	6	Fisher'	

The accompanying diseases, mostly cardiovascular, are more often met in older patients (Table 4). So hypertension is registered in 82.6 % of all patients over 61 years in the work group and in 70 % of the aged patients in the control group.

Comorbidity is also more pronounced in the subgroups of patients aged over 61 years. Only 4 (13.3%) adult patients from the control group and 2 (8.7%) patients from the work group did not report accompanying diseases. Number and proportions of patients in these single-disease subgroups are 9 (30%), with more than one accompanying disease 17 (56.5%) in the control room group ($\chi^2 = 10.3$, $p = 0.006$) and respectively 12 (52.2%), and 9 (39.1 %) experimental group ($\chi^2 = 10.4$, $p = 0.005$) (Table 5).

Table 5 . Comorbidity of the patients in the control group and the work group divided by age subgroups

Comorbidity		Adults groups			p (χ2)
		up to 60 (incl.) (N = 32)	from 61 (N = 30)	Total	
Contr. group	Without accompanying disease	12 (37.5 %)	4 (13.3 %)	16 (25.8 %)	0.006
	One accompanying disease	14 (43.8 %)	9 (30.0 %)	23 (37.1 %)	
	More from one accompanying disease	6 (18.8%)	17 (56.7%)	23 (37.1%)	
	Total	32 (100.0 %)	30 (100.0 %)	62 (100.0 %)	
Work group	Without accompanying disease	17 (43.6 %)	2 (8.7 %)	19 (30.6%)	0.005
	One accompanying disease	17 (43.6 %)	12 (52.2 %)	29 (46.8 %)	
	More from one accompanying disease	5 (12.8 %)	9 (39.1%)	12 (19.4 %)	
	Total	39 (100%)	23 (100%)	62(100%)	

According to the classification on WHO for the severity of the COVID-19 disease, both the control and work group included patients with COVID-19 pneumonia, without need for oxygen therapy and patients with severe COVID-19 pneumonia, requiring oxygen therapy. In both groups there prevail the patients with severe pneumonia: 57 (91.9%) for the group with RR and 53 (85.5%) persons for the control group, as the distribution of the sign by number of patients in the two groups has no statistically significant difference (Figure 7).

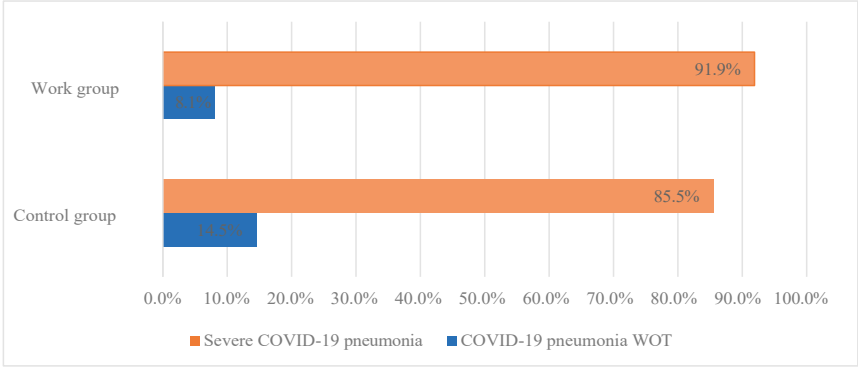


Figure 7. Distribution of the patients by severity of the pneumonias in the surveyed and control groups according to WHO criteria

In the age subgroups, the severity of pneumonia in both groups shows similar trend: from 87.5% to 89.7% of the patients aged up to 60-years and from 83.3% and 95.7% in older patients with severe course of COVID-19 pneumonia (Table 6)

Table 6. Comparison on the severity of the pneumonia in the patients in age subgroups of the control and work groups

Severity of pneumonia , n (%)	Up to 60 y (incl.)		Stat. test	P	From 61 y. on		Stat. test	P
	Control group (N=32)	Work Group (N=39)			Control group (N=30)	Work Group (N=23)		
COVID- 19 pneumonia WOT	4 (12.5%)	4 (10.3%)	Fisher's ET	1,000	5 (16.7%)	1 (4.3%)	Fisher's ET	0.217
Severe COVID-19 pneumonia	28 (87.5%)	35 (89.7%)			25 (83.3%)	22 (95.7%)		
Total	32 (100%)	39 (100%)			30 (100%)	23 (100%)		

4.2. Analysis of blood gas analysis parameters upon admission in the patients from both the control and the work group

The indicators from the blood gas analysis on the day of admission show lower values of pH, pO2 and SatO2%.

The values on pCO2 in men from the surveyed group are higher in comparison with the men from the control group, with confirmed statistical significance (p = 0.001).

In women the indicators are almost equal, with exception of pCO2 which in women from the control group, as well as in the men has a lower value 4.36 (0.9) vs 4.94 (1.39) in the experimental one (Table 7). All indicators of the BGA, except pH, in both genders show the values under their normal limits.

Table 7. Indicators from blood gas analysis on the day of admission in men and in women in the control and work group

Indicators from the BGA on the day of admission	Groups	Men			Women		
		N	Mean (SD)	p (t)	N	Mean (SD)	p (t)
PH	control	31	7.46 (0.08)	0.562	31	7.44 (0.05)	0.932
	Work	27	7.44 (0.04)		35	7.44 (0.05)	
pO2, kPa	control	31	9.01 (1.42)	0.157	31	8.82 (1.44)	0.992
	Work	27	8.46 (1.49)		35	8.83 (1.6)	
pCO2, kPa	control	31	4.2 (0.72)	0.001*	31	4.36 (0.9)	0.054
	Work	27	4.95 (0.95)		35	4.94 (1.39)	
Saturation, %	control	31	94.01 (2.22)	0.066	31	93.17 (2.57)	0.495
	Work	27	92.67 (3.2)		35	93.61 (2.69)	

The results from blood gas analysis report lower entry indicators in the experimental group, both in younger patients (subgroup up to 60 years incl.), and in the group with older patients of pH, pO2 and saturation and higher of pCO2 (Table 8).

Table 8. Indicators from blood gas analysis on the day of admission in the same age subgroups in the control and work groups

Age groups	Indicators from BGA on the day of admissio	Gr.	N	Mean (SD)	ME	IQR	Min	Max	Mean dif	Test	P
Up to 60 years incl.	PH	1	32	7.46 (0.08)	7.45	0.05	7.33	7.84	0.02	MW-U- test	0.542
		2	39	7.44 (0.04)	7.46	0.08	7.34	7.52			
	pO2, kPa	1	32	8.72 (1.3)	8.55	1.52	6.80	11.90	0.06	Student t-test	0.840
		2	39	8.65 (1.32)	8.90	2.00	6.40	11.50			
	pCO2, kPa	1	32	4.25 (0.76)	4.34	1.10	2.60	5.50	- 0.64	MW-U- test	0.015*
		2	39	4.9 (1.11)	4.67	1.28	2.47	8.00			
	Saturation , %	1	32	93.27 (2.56)	93.30	2.80	88.00	97.40	0.09	MW-U- test	0.963
		2	39	93.18 (2.8)	94.00	4.00	87.90	97.00			
61 and on	PH	1	30	7.45 (0.1)	7.45	0.08	7.28	7.90	0.01	MW-U- test	0.836
		2	23	7.44 (0.04)	7.44	0.06	7.30	7.51			
	pO2, kPa	1	30	9.13 (1.53)	9.15	1.71	6.04	12.34	0.44	Student t-test	0.357
		2	23	8.69 (1.91)	9,14	2.43	4.66	12,10			
	pCO2, kPa	1	30	4.31 (0.88)	4.40	1.23	1.58	5.52	- 0.71	MW-U- test	0.031*
		2	23	5.02 (1.38)	4.90	0.85	2.00	8.90			
	Saturation , %	1	30	93.93 (2.24)	94.00	2.70	88.50	97.40	0.7	MW-U- test	0.590
		2	23	93.23 (3.23)	94.00	2.70	84.70	98.00			

1 – control a group; 2 – work group

In patients with subsequent course of a more severe form of pneumonia (Severe COVID-19 pneumonia) the indicators of the BGA upon admission registered lower values in the work group in comparison with the control one,

with exception on pCO2, where the ratio is vice versa (Table 9).

Table 9 . Indicators from blood gas analysis in the day on accepts at the same degrees of severity of pneumonia in the control and work groups

Severity of then pneu-monia	Indicators from BGA on the day of admission	Gr.	N	Mean (SD)	ME	IQR	Min	Max	Mean diff	Test	P
Severe COVID-19 pneumonia	PH	1	53	7.45 (0.1)	7.45	0.07	7.28	7.90	0.012	MW-U- test	0.759
		2	57	7.44 (0.04	7.45	0.06	7.30	7.52			
	pO2	1	53	8.76 (1.42	8.56	1.57	6.04	12.34	0.243	Student t-test	0.388
		2	57	8.52 (1.51	8.70	2.00	4.66	12.10			
	pCO2	1	53	4.32 (0.79	4.40	1.15	1.58	5.52	-0.671	MW-U- test	0.002*
		2	57	4.99 (1.24	4.80	1.16	2.00	8.90			
	Saturation	1	53	93.32 (2.45	93.80	2.90	88.00	97.40	0.344	MW-U- test	0.769
		2	57	92.98 (2.94	93.40	3.40	84.70	98.00			
COVID-19 pneumonia WOT	PH	1	9	7.44 (0.05	7.45	0.04	7.34	7.50	0.019	Student t-test	0.527
		2	5	7.42 (0.07	7.40	0.08	7.34	7.50			
	pO2	1	9	9.81 (1.14	9.81	0.93	7.92	11.50	-0.516	Student t-test	0.413
		2	5	10.33 (0.98	10.70	1.37	9.20	11.50			
	pCO2	1	9	4.06 (0.95	4.12	1.27	2.60	5.25	-0.324	Student t-test	0.510
		2	5	4.39 (0.63	4.34	0.15	3.54	5.30			
	Saturation	1	9	95.17 (1.53	95.00	1.60	92.50	97.40	-0.593	Student t-test	0.473
		2	5	95.76 (1.24	95.50	1.50	94.00	97.00			

1 – control group; 2 – work group

4.3. Analysis of BGA indicators in patients from the control group and work group during treatment in the Clinic

4.3.1. Comparison between the men from the group patients with RR and the control group

The male patients and severe pneumonia in the group with RR are 25 (92.6%) and they underwent oxygen therapy with an average value of the maximum debit 8.36 (4.46) l/min. In the control group in 27 (87.1%) of the male patients oxygen therapy was applied with average maximum debit of 6.56 (4.06) l/min. (Figure 8).

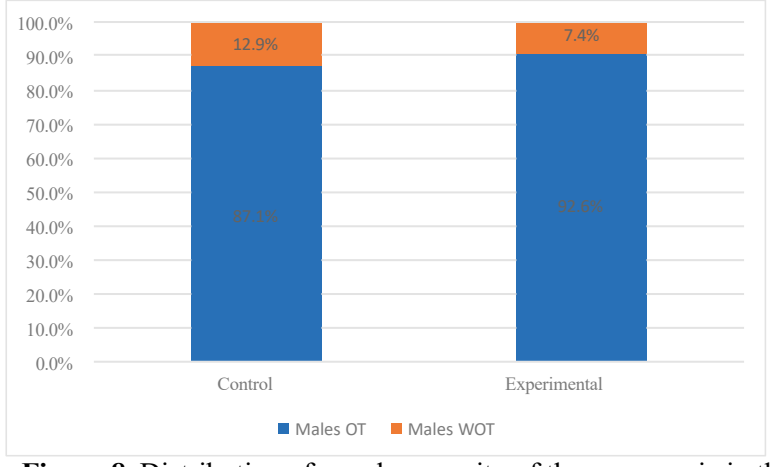


Figure 8. Distribution of men by severity of the pneumonia in the surveyed and the control groups

OT- oxygen therapy WOT- without oxygen therapy

Comparison of the indicators from the BGA for the 1st, 3rd day and upon discharge of men in each group is presented in Table 10.

Table 10. Indicators from blood gas analysis during treatment in men in the control and work groups

BGA indicator	Stage of hospital stay, males	Group*	Mean (SD)	Median	Stat. test	P	Post Hoc Test (Ptukey/Durbin-Conover)		
							Meandif 1- 3 day	Meandif 3-day - discharge	Meandif 1-day discharge
PH	1-day	1 (31)	7.46 (0.08)	7.45	F (Rep. MANOVA) = 7.13	0.002	0.0487 (p = 0.004)	-0.0161 (p = 0.284)	0.0326 (p = 0.284)
	3-day	1 (31)	7.41 (0.05)	7.41					
	Discharge	1 (31)	7.42 (0.05)	7.44					
	1-day	2 (27)	7.44 (0.04)	7.45	χ^2 (Friedman) = 3.47	0.177	p = 0.214	p = 0.07	p = 0.556
	3-day	2 (27)	7.43 (0.04)	7.43					
	Discharge	2 (27)	7.42 (0.06)	7.43					
PO2	1-day	1 (31)	9.01 (1.42)	8.73	F (Rep. MANOVA) = 13	<0.001	-1.52 (p<0.001)	1.231 (p<0.001)	-0.285 (p = 0.57)
	3-day	1 (31)	10.53 (1.59)	10.32					
	Discharge	1 (31)	9.3 (1.21)	8.9					
	1-day	2 (27)	8.46 (1.49)	8.93	F (Rep. MANOVA) = 7.78	0.001	-1.286 (p = 0.002)	-0.368 (p = 0.728)	- 1.654 (p = 0.006)
	3-day	2 (27)	9.75 (1.4)	9.7					
	Discharge	2 (27)	10.12 (2.09)	9.5					
PCO2	1-day	1 (31)	4.2 (0.724)	4.36	F (Rep. MANOVA) = 16.2	<0.001	-1.213 (p<0.001)	0.586 (p = 0.05)	-0.627 (p =0.05)
	3-day	1 (31)	5.42 (1.212)	5.38					
	Discharge	1 (31)	4.83 (0.831)	4.8					
	1-day	2 (27)	4.95 (0.948)	4.8	χ^2 (Friedman) = 17.4	<0.001	p <0.001	p = 0.122	p = 0.002
	3-day	2 (27)	5.5 (0.705)	5.5					
	Discharge	2 (27)	5.44 (0.745)	5.5					
Saturation	1-day	1 (31)	94.01 (2.22)	94	F (Rep. MANOVA) = 2.97	0.06	-1.05 (p=0.095)	1.00 (p = 0.13)	-0.04 (p =0.99)
	3-day	1 (31)	95.06 (2.11)	95.7					
	Discharge	1 (31)	94.05 (2.14)	94					
	1-day	2 (27)	92.67 (3.2)	94	χ^2 (Friedman) = 8.52	0.014	p = 0.005	p = 0.59	p = 0.02
	3-day	2 (27)	94.77 (1.74)	95					
	Discharge	2 (27)	94.76 (2.35)	95					

*1 – control group; 2 – work group

Comparison of the indicators from BGA upon discharge of the men of both groups, as well as the dynamics in the indicators is presented in Table 11.

Table 11. Comparison between the indicators from blood gas analysis upon discharge in men in the control and work groups

KBA indicators (day of discharge/ difference in (discharge-hospitalization)	Group*	Mean (SD)	Median	Stat.test	R
PH	1 (31)	7.42 (0.05)	7.44	Mann - Whitney U	0.734
	2 (27)	7.42 (0.06)	7.43		
PO2	1 (31)	9.3 (1.21)	8.9	Mann - Whitney U	0.085
	2 (27)	10.12 (2.09)	9.5		
Difference in pO2 (discharge - hospitalization)	1 (31)	0.29 (±1.54)	0.09	Mann - Whitney U	0.03
	2 (27)	1.65 (±2.52)	1.3		
PCO2	1 (31)	4.83 (0.831)	4.8	Student t-test	0.005
	2 (27)	5.44 (0.745)	5.5		
Difference in saturation-so (discharge - hospitalization)	1 (31)	0.05 (2.66)	- 0.1	Student t-test	0.017
	2 (27)	2.1 (3.66)	1.9		

*1 – control group; 2 – work group

The pH indicators during the men's stay in the covid ward from the control group show reduction by the 3rd day to 7.41 (0.05), as the difference is statistically significant (Mean $_{dif}$ = 0.049, SE = 0.01, p $_{tukey}$ = 0.002) and with slight rise by the discharge - 7.42 (0.05). In the experimental group there is not significant dynamics observed and they remain in the limits of the normal up to the discharge. The comparison on pH between the men of the two groups upon discharge showed the same results.

On the 3rd day, in the men in the control group, pO2 increased within the normal range - 10.53 (1.59) kPa, and at the time of discharge, a decrease was observed to 9.3 (1.21) kPa. Post hoc tests for difference show that the dynamics with statistical significance positive-between 1st and 3 day (M $_{dif}$ = 1.52, SE = 0.3, p_{tukey} <.001) and negative between the 3rd day and the day of discharge(M $_{diff}$ = 1.23, SE = 0.29, r $_{tukey}$

< 0.001). The difference between day 1 and the day of discharge is statistically insignificant $M_{dif} = 0.23$, SE = 0.29, $p_{tukey} = 0565$).

In the work group the trend is ascending during the whole treatment from 8.46 (±1.49) kPa on the day of admission, 9.75 (±1.4) kPa, by the third day and 10.12 (±2.09) kPa., with statistically significant difference reported (F (2, 52) =7.78; p = 0.001). Post hoc difference tests show that the main dynamics is positive and occurs between day 1 and day 3 ($M_{dif} = 1.29$, SE = 0.34, $p_{tukey} = 0.002$). The difference between day 1 and the day of discharge is $M_{dif} = 1.65$, SE = 0.48, $p_{tukey} = 0.005$. The average values with 95% confidence interval of pO2 in men are shown in figure (9).

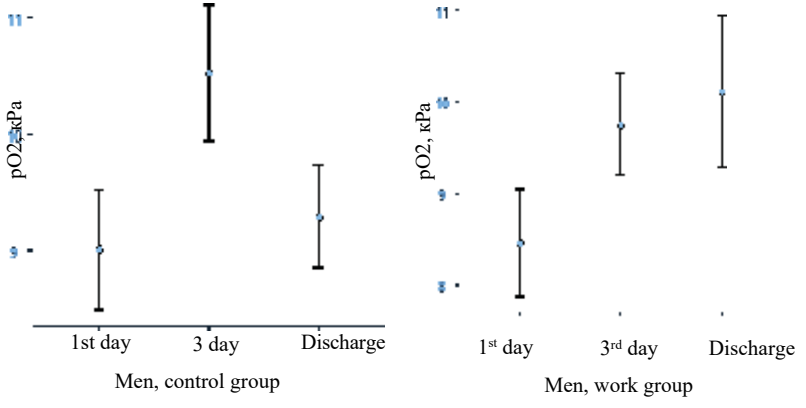


Figure 9. Average values of pO2 in men in the control and work group

Although no statistically significant difference is reported upon comparing pO2 on the day of discharge between the men of the two groups, the indicator for difference in pO2 between the 1st and last day of hospital treatment showed statistical significance in favor of the surveyed group ($pO2_{men, control group}$ was 0.29 (1.54) and $pO2_{men,. exp. group}$ was 1.65 (2.52), p = 0.03).

Concerning pCO2 the values on the 3rd day in patients from the control group increasing of the normal values 5.42 (1.212) is observed, after which however there is decline upon discharge 4.83 (0.831). The work group shows normalization of the values by the 3rd day

(p ≤ 0.001) and slight decrease within normal limits (p = 0.122). Keeping the values of pCO2 in reference limits in the work group reported statistical significance compared to the control group (t = –2.91 p = 0.005).

The saturation indicators for men in the control group did not show significant dynamics during the period of hospital treatment, slight rise was fixed by the 3rd day and subsequent reduction to 94.05 (2.14) upon discharge, remaining at the lower border of the reference values.

In men in the experimental group, from the 1st to the 3rd day, the saturation reached 94.77 (1.74) (p ≤ 0.001), keeping the value by discharge.

Observed is statistically significant difference in the indicator for difference in the saturation (discharge - hospitalization) in men from both groups (p < 0.017).

4.3.2. Comparison between the women from the group with RR and the control group

The female patients and severe pneumonia in the work group are 32 (91.4%) and underwent oxygen therapy with average value on the maximum debit 8.63 (± 4.57) l/min. In the control group 26 (83.9%) of the women had applied oxygen therapy with average maximum debit 7.62 (± 4.28) l/min. (Figure 12).

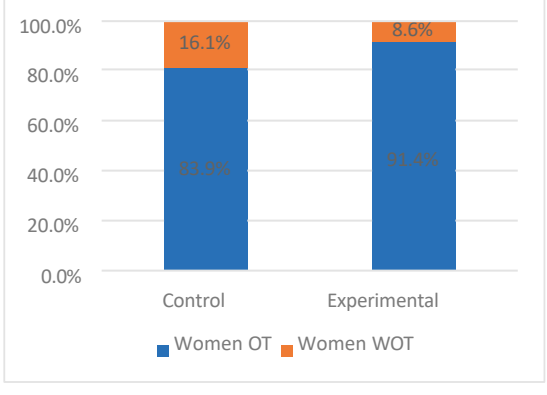


Figure 10. Distribution of the women by severity of the pneumonia in the surveyed and control groups

The average pH upon admission to the covid ward in the women of the surveyed group was 7.44 (±0.05), and on the day of discharge was 7.45 (±0.04).

The average pO2 value on the day of admission for the women in the group with respiratory rehabilitation was 8.83 kPa (±1.6), and on the day of discharge was 9.55 kPa (±1.9). A statistically significant difference is reported for women in pO2 on the 3rd day ($p < 0.025$) between the control and the work group. For the difference in the difference in pO2 indicator (discharge and hospitalization), no statistically significant dependence was found.

Concerning the average value of pCO2 on the day of admission for women from the work group and for women from the control group, no statistically significant difference was observed. For average pCO2 values on the 3rd day ($b < 0.015$) and upon discharge ($b < 0.019$) this difference is indicative, as pCO2 lowers upon discharge. The average value of saturation on the day of admission is 93.61 (±2.69) and on the day of discharge was 94.5 (±2.79) for the women from the group with RR. In women no statistically significant difference is observed in the indicator for saturation upon admission, discharge and difference in saturation (discharge - hospitalization).

4.3.3. Comparison between the persons in age group up to 60 years incl.

Table 12. Comparison of the indicators from blood gas analysis between persons in the age group up to 60 years, incl. from the studied and control groups

Indicators of BGA	Gr.	N	Mean (SD)	ME	IQR	Min	Max	Mean diff	Test	P
Maximum debit of O2, l/min.	1	28	7.36 (4.14)	6.00	5.50	2.00	15.00	- 1.07	Mann–Whitney U-test	0.402
	2	35	8.43 (4.32)	6.00	7.00	3.00	15.00			
PH on the day of admission	1	32	7.46 (0.08)	7.45	0.05	7.33	7.84	0.02	Mann–Whitney U-test	0.542
	2	39	7.44 (0.04)	7.46	0.08	7.34	7.52			
PH on the 3rd day	1	32	7.41 (0.04)	7.41	0.04	7.32	7.50	- 0.01	Mann–Whitney U-test	0.082
	2	39	7.42 (0.04)	7.42	0.05	7.30	7.51			
PH upon discharge	1	32	7.43 (0.07)	7.44	0.04	7,12	7.58	- 0.01	Student t-test	0.478
	2	39	7.44 (0.06)	7.44	0.08	7.17	7.52			

Indicators of BGA	Gr.	N	Mean (SD)	ME	IQR	Min	Max	Mean dif	Test	P
Difference in PH (discharge - hospitalization)	1	32	-0.03 (0.09)	-0,03	0,06	-0,36	0,13	-0,03	Mann–Whitney U-test	0,482
	2	39	-0.01 (0.06)	0,00	0,08	-0,24	0,10			
pO2 on the day of admission	1	32	8.72 (1.3)	8,55	1,52	6,80	11,90	0,06	Student t-test	0,840
	2	39	8.65 (1.32)	8,90	2,00	6,40	11,50			
pO2 on day 3	1	32	10.73 (1.83)	10,36	2,90	7,29	15,50	1,08	Student t-test	0,008
	2	39	9.65 (1.51)	9,70	1,30	5,05	12,80			
pO2 upon discharge	1	32	9.02 (1.08)	9,05	1,30	6,53	11,30	-0,84	Mann–Whitney U-test	0,47*
	2	39	9.86 (1.78)	9,49	2,60	7,20	14,36			
Difference in pO2 (discharge – hospitalization)	1	32	0.3 (1.76)	0,20	2,01	-4,32	3,72	-0,90	Student t-test	0,056
	2	39	1.2 (2.08)	0,80	2,40	-2,56	6,36			
pCO2 on the day of admission	1	32	4.25 (0.76)	4,34	1,10	2,60	5,50	-0,64	Mann–Whitney U-test	0,015*
	2	39	4.9 (1.11)	4,67	1,28	2,47	8,00			
pCO2 on the 3rd day	1	32	5.25 (1.17)	5,06	1,47	3,02	7,50	-0,38	Student t-test	0,125
	2	39	5.63 (0.91)	5,60	1,20	4,30	9,43			
pCO2 upon discharge	1	32	4.78 (0.92)	4,91	1,20	3,21	7,28	-0,84	Student t-test	0,004*
	2	39	5.62 (1.37)	5,50	1,40	2,50	12,00			
Difference in pCO2 (discharge – admission)	1	32	0.52 (1.15)	0,36	1,50	-0,99	4,68	-0,20	Student t-test	0,560
	2	39	0.72 (1.63)	0,83	1,20	-4,30	7,33			
Saturation on the day of admission	1	32	93.27 (2.56)	93,30	2,80	88,00	97,40	0,09	Mann–Whitney U-test	0,963
	2	39	93.18 (2.8)	94,00	4,00	87,90	97,00			
Saturation on the 3rd day	1	32	95.17 (2.13)	95,80	2,95	89,70	100,00	0,66	Student t-test	0,216
	2	39	94.51 (2.29)	95,00	2,00	86,00	97,50			
Saturation upon discharge	1	32	93.96 (2.19)	94,15	2,75	87,80	98,00	-0,76	Mann–Whitney U-test	0,093
	2	39	94.72 (2.45)	95,00	4,00	88,00	98,20			
Difference in saturation (discharge – admission)	1	32	0.69 (3.46)	0,35	4,10	-6,20	8,30	-0,85	Student t-test	0,311
	2	39	1.54 (3.53)	1,40	4,70	-6,20	9,10			

1 – control group; 2 – work group

Patients in the RR group in the age group up to 60 years (n 35) underwent oxygen treatment with a mean maximum flow rate of 8.43 (± 4.32) (Figure 11).

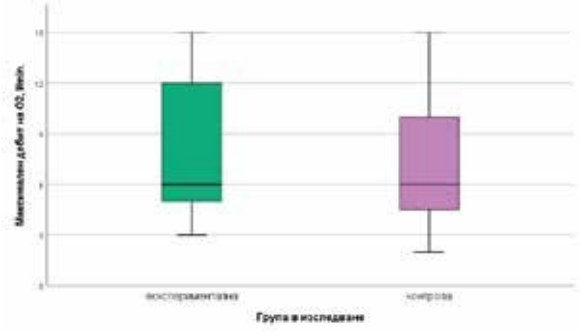


Figure 11. Comparison between the values of the maximum debit of O2 l/min., used in the treatment of the patients from the surveyed and the control group

The median PH upon admission to the covid ward for persons up to 60 years of age from the surveyed group is 7.44 (± 0.04), and on the day of discharge is 7.44 (± 0.06). These pH values are within the reference values (Figure 12).

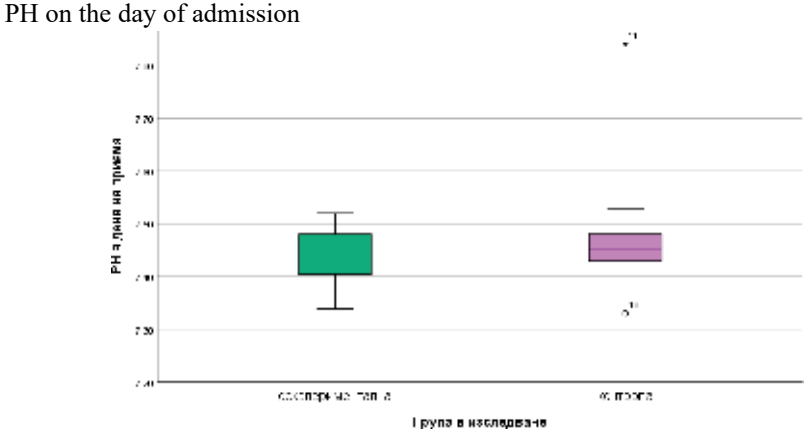


Figure 12. Comparison between the values of PH on the day of admission in patients from the surveyed and the control groups

The median of **pO2** in the day of admission for the subgroup of up to 60 y. of the group with respiratory rehabilitation is 8.65 (± 1.32), and on the day of discharge is 9.86 (± 1.78) (Figure 13).

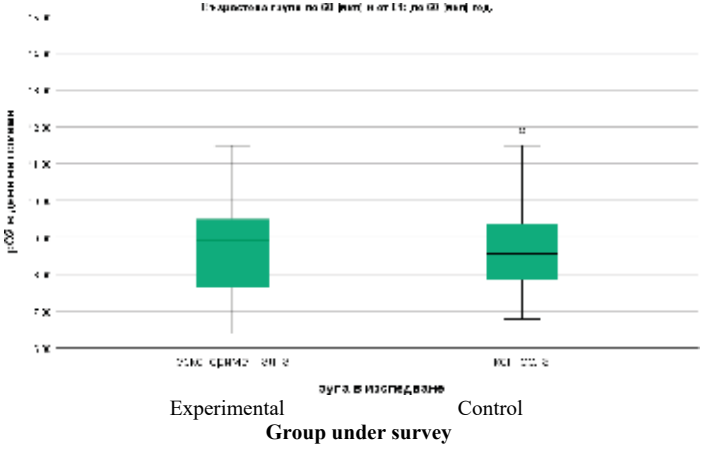


Figure 13. Comparison of oxygen partial pressure values (pO2) on the day of admission between the patients from the surveyed and the control group

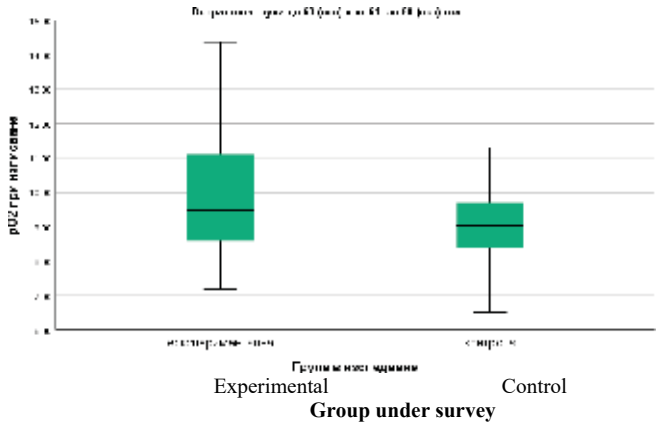


Figure 14. Comparison of the values of the partial pressure of oxygen (pO2) on the day of discharge between patients in the study and the control group

No statistically significant difference was reported when comparing PH, pO2 on the day of discharge between the patients up to 60 y. from the patients who undergo breathing exercises and the control group, as well as for the sign difference in pO2 (discharge and hospitalization) (Figure 13, Figure 14, Figure 15).

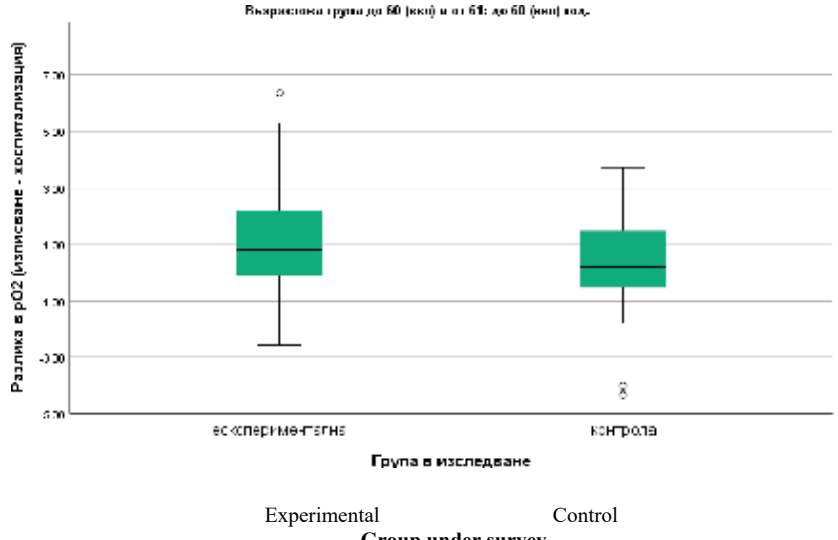


Figure 15 . Comparison on the values of the difference in pO2 (discharge - hospitalization) in the patients from the surveyed and the control group

The median of pCO2 on the day of admission for the 60-year aged subgroup is 4.9 (±1.11) for the patients with RR and 4.25 (± 0.76) for the control group. The median of pCO2 upon discharge for the work group is 5.62 (±1.37) and 4.78 (± 0.92) for the control group. Concerning pCO2, upon admission ($p < 0.015$) and discharge ($p < 0.004$) statistically significant difference is reported between persons aged up to 60 years in both groups and decrease in pCO2 indicator upon discharge. Median saturation on day of admission is 93.18 (±2.8) for the patients who conduct DR, and 93.27 (± 2.56) for the control group. On the day of discharge, the median saturation was 94.72 (± 2.45) for patients up to 60 years old in the work group. No statistically significant difference was observed in the saturation indicators during admission, upon discharge and difference in the saturation (discharge – hospitalization) in patients aged up to 60 years between the two groups.

4.3.4. ***Comparison between the persons in the age group over 61 years***

Table 13 . Comparison of the indicators from blood gas analysis between individuals in the age group > 61 years for the surveyed and control group

Blood gas analysis indicators	**Gr.**	**N**	**Mean (SD)**	**ME**	**IQR**	**Min**	**Max**	**Mean dif**	**Test**	**P**
Maximum debit of O2, l/min.	1	25	6.76 (4.26)	5,00	6,00	2,00	15,00	-1,876	Mann–Whitney U-test	0,150
	2	22	8.64 (4.84)	7,00	11,00	2,00	15,00			
PH on the day of admission	1	30	7.45 (0.1)	7,45	0,08	7,28	7,90	0,009	Mann–Whitney U-test	0,836
	2	23	7.44 (0.04)	7,44	0,06	7,30	7,51			
PH on day 3	1	30	8.74 (7.23)	7,44	0,07	7,27	47,00	1,302	Mann–Whitney U-test	0,607
	2	23	7.44 (0.03)	7,45	0,07	7,40	7,49			
PH upon discharge	1	30	7.43 (0.05)	7,42	0,07	7,34	7,54	-0,020	Student t-test	0,121
	2	23	7.45 (0.04)	7,45	0,08	7,38	7,53			
Difference in PH (discharge – hospitalization)	1	30	-0.02 (0.1)	-0,01	0,09	-0,44	0,11	-0,029	Mann–Whitney U-test	0,211
	2	23	0.01 (0.05)	0,02	0,06	-0,11	0,15			
pO2 on the admission day	1	30	9.13 (1.53)	9,15	1,71	6,04	12,34	0,439	Student t-test	0,357
	2	23	8.69 (1.91)	9,14	2,43	4,66	12,10			
pO2 on day 3	1	30	10.67 (2.48)	10,55	2,73	6,80	19,19	0,919	Student t-test	0,133
	2	23	9.75 (1.68)	9,50	2,30	7,10	13,20			
pO2 upon discharge	1	30	9.45 (1.46)	9,14	1,91	5,70	13,20	-0,233	Mann–Whitney U-test	0,829
	2	23	9.69 (2.34)	8,90	2,90	6,50	16,70			
Difference in pO2 (discharge – hospitalization)	1	30	0.33 (1.91)	0,34	2,09	-3,67	5,28	-0,671	Student t-test	0,316
	2	23	1 (2.9)	0,70	3,30	-3,60	8,00			
pO2 on the day of admission	1	30	4.31 (0.88)	4,40	1,23	1,58	5,52	-0,706	Mann–Whitney U-test	0.031*
	2	23	5.02 (1.38)	4,90	0,85	2,00	8,90			
pO2 on the 3rd day	1	30	5.19 (1.06)	5,20	1,41	3,53	7,87	-0,276	Student t-test	0,297
	2	23	5.47 (0.77)	5,50	0,80	3,60	7,20			
pO2 upon discharge	1	30	5 (0.74)	4,90	0,91	3,73	6,95	-0,406	Student t-test	0.030*
	2	23	5.4 (0.53)	5,30	0,60	4,00	6,30			

Blood gas indicators analysis	Gr.	N	Mean (SD)	ME	IQR	Min	Max	Mean diff	Test	P
Difference in pO2 (discharge - hospitalizatio n)	1	30	0.69 (1.18)	0.59	1.44	- 1.20	3.72	0.300	Student t-test	0.393
	2	23	0.38 (1.31)	0.51	1.20	- 3.20	3.10			
Saturation on the day of admission	1	30	93.93 (2.24)	94.00	2.70	88.50	97.40	0.696	Mann–Whitney U-test	0.590
	2	23	93.23 (3.23)	94.00	2.70	84.70	98.00			
Saturation on the 3rd day	1	30	95.36 (2.9)	96.00	3.00	87.00	100.00	0.839	Student t-test	0.260
	2	23	94.52) (2.29)	95.00	3.00	89.00	98.00			
Saturation Upon discharge	1	30	93.87 (2.97)	93.95	2.30	82.00	98.80	- 0.565	Mann–Whitney U-test	0.388
	2	23	94.43 (2.87)	94.00	4.00	87.00	99.00			
Difference in the saturation (discharge - admission)	1	30	-0.06 (2.8)	- 0.15	2.40	- 6.50	6.30	- 1,261	Student t-test	0.191
	2	23	1.2 (4.12)	1.00	5.00	- 7.60	8.30			

*1 – control group; 2 – work group

There were 23 patients in the experimental group aged over 61 years and they underwent oxygen therapy with average value on the maximum debit 8.64 (4.84). The number of the patients from the control group aged over 61 years are 30 and have undergone oxygen therapy with an average value of the maximum debit 6.76 (4.26). The median of the PH indicator upon admission in the covid ward in the persons from 61 years age from the studied group is 7.44 (0.04), and on the day of discharge it is 7.45 (0.04). Regarding the PH indicator, no statistically significant difference was discovered between the control and the experimental group both upon admission and upon discharge.

The median pO2 on the day of admission for the 61-year-old subgroup of the group with respiratory rehabilitation is 8.69 (1.91), and on the day of discharge was 9.69 (2.34). No statistically significant difference was reported when comparing pO2 on the day of admission and the day of discharge between patients aged 61 years, who performed breathing exercises, and the control group, as well as for the sign for difference in pO2 (discharge and hospitalization). The median of pCO2 on the day of admission for the

subgroup aged 61-years and on is 5.02 (1.38) for the work group. pCO2 upon discharge is 5.4 (0.53) for the group with RR and 5 (0.74) for the control group. In terms of pCO2, upon admission ($p < 0.031$) and discharge ($p < 0.030$) a statistically significant difference is reported between the 61-year-old aged ones in both groups. Median saturation on the day of admission was 93.23 (3.23) for the group with RR and 93.93 (2.24) for the control group. The median of the saturation in the day on writing is 94.43 (2.87) for patients older than 61 years in the work group. No statistically significant difference is observed in the indicator of saturation upon admission, saturation upon discharge and difference in the saturation (discharge – hospitalization) in patientsaged over 60 years from both groups.

4.3.4. Comparison between patients from the group with RR and a control group with severe pneumonia

Table 14. Comparison between patients from the group with RRf and the control group with severe pneumonia

Criterion	control	experimental	Total	P (Fisher's ET)
COVID-19 pneumonia with no requirement for supplemental oxygen, n (%)	9 (14.5)	5 (8.1)	14 (11.3)	0.395
Severe COVID- 19 pneumonia, n (%)	53 (85.5)	57 (91.9)	110 (88.7)	

The number of the patients with severe pneumonia from the work group is 57, and from the control group is 53. Patients, who do not need reception of oxygen in the control group were 9, and from the RR group were 5.

Table 15. Comparison on the indicators from blood gas analysis in the patients with severe pneumonia from the studied and control groups

Blood gas analysis indicators	Gr.	N	Mean (SD	ME	IQR	Min	Max	Mean dif	Test	P
Maximum O2 debit, l/min.	1	53	7.08 (4.16)	6,00	6,00	2,00	15,00	-1,433	Mann–Whitney U-test	0,870
	2	57	8.51 (4.48)	6,00	7,00	2,00	15,00	-1,433		
PH on the day of admission	1	53	7.45 (0.1)	7,45	0,07	7,28	7,90	0,01175	Mann–Whitney U-test	0,759
	2	57	7.44 (0.04)	7,45	0,06	7,30	7,52	0,01175		

Blood gas analysis indicators	Gr.	N	Mean (SD	ME	IQR	Min	Max	Mean dif	Test	P
PH on day 3	1	53	8.16 (5.44)	7,41	0,07	7,27	47,00	0,72708	Mann–Whitney U-test	0,048
	2	57	7.43 (0.04)	7,42	0,06	7,30	7,51	0,72708		
PH upon discharge	1	53	7.43 (0.06)	7,43	0,05	7,12	7,58	-0,01212	Mann–Whitney U-test	0,139
	2	57	7.44 (0.05)	7,44	0,08	7,17	7,53	-0,01212		
Difference in PH (discharge – admission)	1	53	-0.03 (0.1)	-0,02	0,06	-0,44	0,13	-0,02386	Mann–Whitney U-test	0,178
	2	57	0 (0.06)	0,00	0,07	-0,24	0,15	-0,02386		
pO2 on the day of admission	1	53	8.76 (1.42)	8,56	1,57	6,04	12,34	0,24255	Student t-test	0,388
	2	57	8.52 (1.51)	8,70	2,00	4,66	12,10	0,24255		
pO2 on the 3rd day	1	53	10.81 (2.25)	10,59	2,91	6,80	19,19	1,14588	Mann–Whitney U-test	0.005*
	2	57	9.66 (1.6)	9,67	1,80	5,05	13,20	1,14588		
pO2 upon discharge	1	53	9.12 (1.17)	9,05	1,32	5,70	11,64	-0,60357	Mann–Whitney U-test	0,283
	2	57	9.73 (2.05)	9,20	2,60	6,50	16,70	-0,60357		
Difference in pO2 (discharge – hospitalization)	1	53	0.36 (1.68)	0,42	1,80	-4,32	3,72	-0,84611	Student t-test	0.0377*
	2	57	1.2 (2.48)	1,30	2,95	-3,60	8,00	-0,84611		
pCO2 on the day of admission	1	53	4.32 (0.79)	4,40	1,15	1,58	5,52	-0,67073	Mann–Whitney U-test	0.002*
	2	57	4.99 (1.24)	4,80	1,16	2,00	8,90	-0,67073		
pCO2 on the 3rd day	1	53	5.33 (1.13)	5,22	1,18	3,02	7,87	-0,28019	Student t-test	0,151
	2	57	5.61 (0.87)	5,60	0,90	3,60	9,43	-0,28019		
pCO2 upon discharge	1	53	4.95 (0.76)	5,00	0,97	3,21	6,95	-0,62233	Mann–Whitney U-test	0.0005*
	2	57	5.57 (1.17)	5,52	1,04	2,50	12,00	-0,62233		
Difference in pCO2 (discharge - admission)	1	53	0.63 (1.02)	0,57	1,42	-1,20	3,72	0,04839	Mann–Whitney U-test	0,933
	2	57	0.58 (1.57)	0,79	1,25	-4,30	7,33	0,04839		
Saturation on the day of admission	1	53	93.32 (2.45)	93,80	2,90	88,00	97,40	0,34356	Mann–Whitney U-test	0,769
	2	57	92.98 (2.94)	93,40	3,40	84,70	98,00	0,34356		

Blood gas analysis indicators	Gr.	N	Mean (SD	ME	IQR	Min	Max	Mean dif	Test	P
Saturation on the 3rd day	1	53	95.22 (2.65)	96.00	3.00	87.00	100.00	0.68442	Mann–Whitney U-test	0.085
	2	57	94.54 (2.25)	95.00	2.00	86.00	98.00	0.68442		
Saturation at writing	1	53	93.76 (2.55)	93.80	2.20	82.00	98.00	- 0.71304	Mann–Whitney U-test	0.091
	2	57	94.48 (2.65)	95.00	4.00	87.00	99.00	- 0.71304		
Difference in saturation (discharge - admission)	1	53	0.44 (3.09)	0.10	3.20	- 6.50	8.30	- 1.05660	Student t-test	0.116
	2	57	1.5 (3.88)	1.90	5.00	- 7.60	9,10	- 1.05660		

The patients from the work group with severe pneumonia underwent oxygen therapy with a mean maximum flow rate of 8.51 (4.48). The number of the patients from the control group with age with severe pneumonia underwent oxygen therapy with an mean maximum flow rate of 7.08 (4.16). The median of PH upon admission to the covid ward in the subjects with severe pneumonia from the surveyed group was 7.44 (0.04), and on the day of discharge is 7.44 (0.05). Concerning the indicator PH no statistically significant difference is found between both groups both upon admission and upon discharge.

The median of pO2 on the day of admission for the severe pneumonia subgroup 8.52 (1.51) for the work group, and on the day of discharge is 9.73 (2.05). No statistically significant difference was reported when comparing pO2 on the day of admission and the day of discharge between the patients with severe pneumonia from the two groups. The mean difference in pO2 (discharge and hospitalization) for the RR group was 1.2 (2.48), significantly higher than that in the control group 0.36 (1.68). In the difference in pO2 (discharge and hospitalization) for patients with severe pneumonia between the two groups statistically significant difference is observed (**$p < 0.0377$**). The median of pCO2 on the day of admission for the subgroup with severe pneumonia age is 4.99 (1.24) for the work group and 4.32 (0.79) for the control group **($p < 0.002$).** pCO2 upon discharge was 5.57 (1.17) for the RR group and 4.95 (0.76) for the control group. Concerning pCO2 upon admission ($p < 0.002$) and discharge ($p < 0.0005$) statistically significant difference is reported between individuals with severe pneumonia in both groups. The median of the saturation on the day of admission was 93.23 (3.23) for the work group and

93.32 (2.45) for the control group. The median of the saturation on the day of discharge was 94.48 (2.65) for the patients with severe pneumonia from the RR group. Statistically significant difference is not observed in the indicator of saturation upon admission, saturation upon discharge and difference in saturation (discharge - hospitalization) in patients with severe pneumonia from both groups.

4.3.5. Comparison between patients from RR patient group and a control group with pneumonia without need from oxygen therapy

The number of the patients with mild pneumonia from the work group is 5, and from the control group – 9.

The median of PH upon admission in the covid ward in the persons with mild pneumonia in the surveyed group was 7.42 (±0.07), and on the day of discharge it was 7.45 (±0.02). Concerning the indicator PH no statistically significant difference was found between both groups both upon admission and upon discharge (Table 16)

Table 16. Indicators from blood gas analysis in patients with pneumonia without the need for oxygen therapy (mild pneumonia)

Indicators from blood gas analysis	Gr.	N	Mean (SD)	ME	IQR	Min	Max	Mean dif	Test	P
PH on the day of admission	1	9	7.44 (0.05	7.45	0.04	7.34	7.50	0.01933	Student t-test	0.527
	2	5	7.42 (0.07	7.40	0.08	7.34	7.50			
PH on the 3rd day	1	9	7.45 (0.03	7.45	0.04	7.41	7.51	0.01733	Student t- test	0.340
	2	5	7.44 (0.04	7.44	0.03	7.38	7.47			
PH upon discharge	1	9	7.42 (0.07	7.43	0.08	7.30	7.51	-0.03178	Student t-test	0.351
	2	5	7.45 (0.02	7.45	0.02	7.44	7.48			
Difference in PH (discharge – a dmission)	1	9	-0.02 (0.06	- 0.01	0.08	- 0.13	0.04	- 0.05111	Student t-test	0.152
	2	5	0.03 (0.05	0.04	0.05	- 0.04	0.10			
pO2 on the day of admission	1	9	9.81 (1.14	9.81	0.93	7.92	11.50	- 0.51600	Student t-test	0.413
	2	5	10.33 (0.98	10.70	1.37	9.20	11.50			
pO2 on the 3rd day	1	9	10.06 (1.31	9.36	1.04	8.91	12.87	0.07889	Student t- test	0.912
	2	5	9.98 (1.15	10.00	0.50	8.50	11.70			
pO2 upon discharge	1	9	9.87 (1.78)	9.39	2.22	7.47	13,20	- 0.71222	Student t-test	0.419
	2	5	10.58 (0.78)	10.70	1.10	9.60	11.50			

Blood gas analysis indicators	Gr.	N	Mean (SD)	ME	IQR	Min	Max	Mean dif	Test	P
Difference in pO2 (discharge - admission)	1	9	0.06 (2.62	- 0.20	2.60	- 4.01	5.28	- 0.19622	Student t-test	0.872
	2	5	0.25 (0.25)	0.30	0.40	0.00	0.57			
pCO2 on the day of admission	1	9	4.06 (0.95)	4.12	1.27	2.60	5.25	- 0.32378	Student t-test	0.510
	2	5	4.39 (0.63)	4.34	0.15	3.54	5.30			
pCO2 on the 3rd day	1	9	4.58 (0.75)	4.38	1.06	3.64	5.99	- 0.54222	Student t-test	0.178
	2	5	5.12 (0.51)	5.10	0.40	4.30	5.60			
pCO2 upon discharge	1	9	4.5 (1.18)	4.20	0.81	3.28	7.28	- 0.67889	Student t-test	0.245
	2	5	5.18 (0.44	5.30	0.20	4.50	5.70			
Difference in pCO2 (discharge - admission)	1	9	0.44 (1.86)	- 0.36	1.10	- 1.02	4.68	- 0.35511	Student t-test	0.688
	2	5	0.79 (0.52)	0.96	0.31	0.00	1.40			
Saturation during the day on accepts	1	9	95.17 (1.53)	95.00	1.60	92.50	97.40	- 0.59333	Student t-test	0.473
	2	5	95.76 (1.24)	95.50	1.50	94.00	97.00			
Saturation on the 3rd day	1	9	95.48 (1.52)	95.70	2.20	93.00	97.40	1.27778	Student t-test	0.281
	2	5	94.2 (2.77)	95.00	3.00	90.00	97.00			
Saturation upon discharge	1	9	94.81 (2.69)	94.60	2.10	90.20	98.80	- 1.38889	Student t-test	0.289
	2	5	96.2 (0.84)	96.00	1.00	95.00	97.00			
Difference in saturation (discharge – admission)	1	9	-0.36 (3.65)	- 0.10	3.40	- 5.50	6.30	- 0.79556	Student t-test	0.535
	2	5	0.44 (0.4)	0.50	0.50	0.00	1.00			

*1 – control group; 2 – work group

The median of pO2 on the day of admission for patients with mild pneumonia from the group with RR was 10.33 (±0.98), a in the day on writing is 10.58 (±0.78). No statistically significant difference was reported when comparing pO2 on the day of admission, on the day of discharge and in the indicator of difference in pO2 (discharge - admission) between the patients with mild pneumonia from both groups. The median pCO2 on the day of admission for the mild pneumonia age subgroup was 4.39 (±0.63) for the work group and 4.06 (±0.95) for the control group. pCO2 upon discharge was 5.18 (±0.44) for patients undergoing rehabilitation, and 4.5 (±1.18) for the control group. Concerning pCO2 upon admission, discharge and the

difference in pCO2 (admission - discharge) did not show a statistically significant difference between persons with mild pneumonia in both groups. The median of saturation on the day of admission is 95.76 (±1.24) for the experimental one and 95.17 (±1.53) for the control group. Median saturation on the day of discharge was 96.2 (±0.84) for patients with mild pneumonia from the work group. No statistically significant difference was observed in the indicator of saturation upon admission, saturation upon discharge and difference in saturation (discharge - hospitalization) in patients with mild pneumonia from both groups.

4.4. Comparative analysis of the functional status of the cardiovascular and respiratory system and tolerance to physical activity in patients from the surveyed group during the rehabilitation in hospital conditions

From the indicators of the blood gas analysis, it follows that pO2 and saturation have improved reliably ($p < 0.05$), with the saturation reaching the normal values.

It should be noted that upon admission, the pH of patients was reported in reference values and did not undergo significant changes.

Significantly improved pO2 values from 8.67 to 9.79 kPa ($p < 0.001$). The value of pCO2 increases by reaching normal values (Table 17)

Table 17. Comparative analysis of the functional state of the cardiovascular and respiratory system in patients from the surveyed group before and after rehabilitation

Characteristics	Ref. values	Period	N	Mean	SD	ME	IQR (Q1;Q3)	Min	Max	Mean Dif	P
pH	7.35–7.45	1	62	7.44	0.04	7.45	0.06 (7.41; 7.47)	7.3	7.5	0.00	0.862[a]
		2	62	7.44	0.05	7.45	0.08 (7.4; 7.478)	7.2	7.5		
pO2	10.5–13.5	1	62	8.67	1.55	8.91	1.96 (7.628; 9.592)	4.7	12.1	-1.13	<.001[b]
		2	62	9.79	1.99	9.30	2.625 (8.425; 11.05)	6.5	16.7		
pCO2	5.1–5.6	1	62	4.94	1.21	4.79	1.11 (4.317; 5.428)	2.0	8.9	- 0.60	<.001[a]
		2	62	5.54	1.13	5.50	0.96 (5.07; 6.03)	2.5	12.0		
SAP	120–140	1	62	124.0	16.62	120.0	20.00 (110; 130)	85.0	175.0	2.52	0.351[a]
		2	62	121.5	10.72	120.0	10.00 (120; 130)	100.0	160.0		
DAP	80	1	62	75.61	7.74	80.00	10.00 (70; 80)	60.0	90.0	- 0.86	0.537[a]
		2	62	76.47	7.20	80.00	10.00 (70; 80)	60.0	90.0		
Saturation	94–98%	1	62	93.20	2.94	94.00	3.30 (92; 95.3)	84.7	98.0	- 1.41	0.004[b]
		2	62	94.62	2.59	95.00	4.00 (93; 97)	87.0	99.0		
HR	60–100	1	62	79.94	9.52	80.00	12.00 (74; 86)	62.0	120.0	0.48	0.738[b]
		2	62	79.45	8.75	77.50	11.00 (74; 85)	64.0	100.0		

1 On the day of admission
2 Upon discharge
[a] Wilcoxon signed-rank test
[b] Student's t-test

Also, despite the fact that 53% of patients in the experimental group had a history of hypertensive disease, upon admission in 25% of the patients SAP (systolic arterial pressure) was measured from 85 to 110 mmHg and 25% between 130 and 175 mmHg, and upon discharge the range of SAP decreased from 85–170 mmHg to 100 and 160 mmHg. DAP (diastolic arterial pressure) is without significant changes.

Saturation reached reference values upon discharge (94.62%), as the difference of the indicator between the admission and discharge is statistically significant (p = 0.004).

Table 18. Comparison of the indicators on the difference in pO2 and the saturation in patients before and after conducting a rehabilitation program in dependence of the gender, age and severity of pneumonia in hospital settings

	Group	N	Mean	SD	ME	Mean Diff	p
Difference in indicators of pO2 upon discharge and upon hospitalization	Male	27	1.65	2.52	1.3	0.934	0.129
	Female	35	0.721	2.24	0.57		
	up to 60 (incl.)	39	1.2	2.08	0.8	0.205	0.748
	from 61 on	23	0.999	2.9	0.7		
	COVID- 19 pneumonia WOT	5	0.254	0.251	0.3	-0.95	0.399
	Severe COVID- 19 pneumonia	57	1.2	2.48	1.3		
Difference in indicators of saturation upon discharge and hospitalization	Male	27	2.1	3.66	1.9	1.21	0.209
	Female	35	0.889	3.75	1		
	up to 60 (incl.)	39	1.54	3.53	1.4	0.334	0.736
	from 61 on	23	1.2	4.12	1		
	COVID- 19 pneumonia WOT	5	0.44	0.404	0.5	-1.06	0.547
	Severe COVID- 19 pneumonia	57	1.5	3.88	1.9		

The difference in the indicators of pO2 and saturation in patients before and after a rehabilitation program depending on gender, age, severity of the pneumonia did not show statistical significance (Table 18).

To assess tolerance to physical exertion on the day of hospitalization it was reported that 21 (33.9%) patients refused to undergo a 30SCT test. For the rest 41 (66.1 %) the average number of standing ups is 8.54 (5.94), as only 50 % of the patients managed to do 10 or more moves. The assessment of the shortness of breath according to the Borg scale showed that 77.5% of the patients reported feeling moderately pronounced (level 3) shortness of breath.

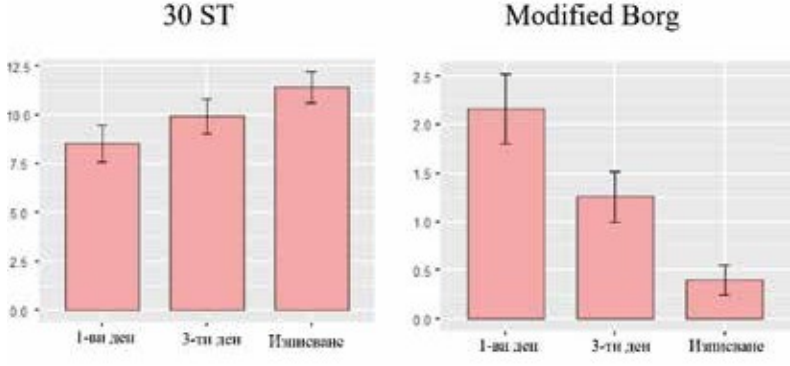
Borg score showed inverse significant correlation with 30SCT test (r = –0.6, p < 0.001) and VAS self-assessment (r = –0.5, p < 0.001). VAS self-assessment in reverse order significantly correlates with depressing (r = -0.5, p < 0.001) and anxiety (r = -0.6, p < 0.001) condition in hospital conditions on the day of admission. The 30SCT test demonstrated positive moderate correlation with VAS (r = 0.4, p = 0.007). A strong positive correlation is also observed between depressing and anxiety condition (r = 0.9, p ≤ 0.001).

Correlations between some laboratory and clinical indicators in patients on the day of admission are presented in Table 19.

Table 19. Correlations between some laboratory and clinical indicators in patients on the day of admission

Pearson correlation	pO2 on the day of admission		SAP in day of admission		DAPL in day of admission		Saturation on the day of admission	
	r	p	r	p	r	p	r	p
HADS-depr. on the day of admission	0.307	0.015	-0.100	0.439	-0.050	0.701	0.362	0.004
30SCT on the day of admission, no.	0.066	0.680	0.332	0.034	0.423	0.006	-0.018	0.913
HADS-anx. On the day of admission self-assessment	0.264	0.038	-0.098	0.449	-0.029	0.823	0.284	0.025

By day 3, patients who refused to complete 30SCT remained 14 , and by the moment of discharge – 12. We are observing statistically significant raise in the results from 30SCT in the surveyed group through the whole period of the rehabilitation (average from 10 (3; 13) to 12 (7; 15) times), $\chi^2 = 47.1$; df = 2; r < 0.001, as well as reduction of the level of breath shortness after the Borg scale at the end of rehabilitation during inpatient treatment: from 87.5% of patients who reported shortness of breath (Borg score > 0) on the day of hospitalization, with an average score after the Borg scale of 1 (0.5; 3), at the end of the active treatment only 8 patients (20%) reported for signs of breath shortness, as the average score decreased to 0 (0; 0) ($\chi^2 = 48.2$; df = 2; p < 0.001) (Fig. 16). The dynamics of the indicators shows raising of tolerance to physical activity, improving the state of the cardiorespiratory system and increasing endurance.



day 1 day 3 Discharge day 1 day 3 discharge

Figure 16. Dynamics of the results from 30 STS and the modified scale of Borg on the 1st day, 3rd day from admission and on the day of discharge

A significant increase in subjective assessment was observed after the VAS scale, as well as a reduction in depressive and anxiety states in hospital conditions from 7 (2; 11.75) to 4 (0.25; 6) points for sensations for depression and from 6 (3; 10.75) to 3 (0; 7) points for anxiety (Table 20).

Table 20. Assessment on the healthy condition with visual analogue scale (VAS) and HADS

Char.	Period	N	Me	Q1;Q3	Min	Max	Stat. test	P	Post Hoc Test (Ptukey/ Durbin-Conover)		
									1st – 3rd day	3rd day - discharge	1st day - discharge
VAS	1st day	62	60	(40;79.75)	0	97	χ^2 (Friedman) = 66.2	<0.001	p <0.001	p <0.001	p <0.001
	3rd day		70	(55;85)	0	100					
	Discharge		80	(70;90)	30	100					
HADS-depr.	1st day	62	7	(2; 11.75)	0	21	χ^2 (Friedman) = 24.8	<0.001	p = 0.011	p <0.001	p = 0.004
	3rd day		5.5	(2; 9)	0	18					
	Discharge		4	(0.25; 6)	0	15					
HADS-anx.	1st day	62	6	(3;10.75)	0	21	χ^2 (Friedman) = 31.0	<0.001	p = 0.001	p <0.001	p = 0.002
	3rd day		4	(1;8)	0	21					
	Discharge		3	(0;7)	0	15					

Towards the end of the treatment, a slight decrease is maintained, but the reverse correlation is maintained between self-assessment by VAS and depression ($r = -0.43$, $p < 0.001$) and anxiety ($r = -0.35$, $p < 0.001$) state in hospital conditions. Observed is a straight correlation between the Borg scale and HADS-depr. ($r = 0.33$, $p < 0.021$) and HADS-anx. ($r = 0.30$, $p < 0.038$). SAP correlates with hypertension ($r = 0.37$, $p < = 0.003$) and the presence of more than one concomitant disease – comorbidity $r = 0.3$, $p \leq 0.027$).

Correlation between other laboratory and clinical indicators is not observed.

4.5. Assessment of the quality of life, related to health measured by EQ-5D-3L –self-assessment of patients with COVID-19, admitted on stationary treatment in the Department of Thoracic Surgery - Covid-19 at UMPHAT "St. Marina" – city of Varna

Upon admission in the stationary, 21% (n = 13) of patients reported no difficulties (problems) in any of the EQ-5D metrics (health profile "11111"), and 79 % (n = 49) indicate difficulties ($\chi^2 = 20.9$, $p < .001$). The number of involved metrics (from 0 to five) is indicated in Table 21.

Table 21. Distribution by number and share of the patients according to the number of areas affected

Number of metrics, affected in patients	Number	%	p(χ^2)
Without difficulties	13	21.0%	0.187
IN one area	15	24.2%	
IN two areas	4	6.5%	
In three areas	10	16.1%	
IN four areas	8	12.9%	
In all areas	12	19.4%	
Total	62	100.0%	

24.2% (n = 15) of patients had serious problems (3rd level of self-assessment) in one or more metrics.

Positive moderate relationships are observed between the number of affected metrics and the level of anxiety (Spearman›s ρ = 0.425, p < .001) and the level of depression state (Spearman's ρ = 0.339, p = .007) on the day of admission.

Most patients indicated the presence of certain difficulties, when carry out the usual ones you are activities (45.2 %, n = 28), as well as complete inability to carry out one's usual activities – 11.3% (n = 7).

The distribution on the levels on problems at self-esteem on the patients in all areas (meters) in the day on accepts are presented in Table 22 and Figure 17.

Table 22 . Distribution on the levels on problems at self-esteem of patients in all areas (meters) on the day of admission

Measures in EQ-5D-3L	Level	Q-ty	%	Total	p (χ2)
Mobility	MOB1	34	54.8%	62	<.001
	MOB2	22	35.5%		
	MOB3	6	9.7%		
Self_care	SC1	40	64.5%	62	<.001
	SC2	20	32.3%		
	SC3	2	3.2%		
Usual activities	UA1	27	43.5%	62	0.001
	UA2	28	45.2%		
	UA3	7	11.3%		
Pain / discomfort	PD1	35	56.5%	62	<.001
	PD2	23	37.1%		
	PD3	4	6.5%		
Anxiety / depression	AD1	29	46.8%	62	0.001
	AD2	26	41.9%		
	AD3	7	11.3%		

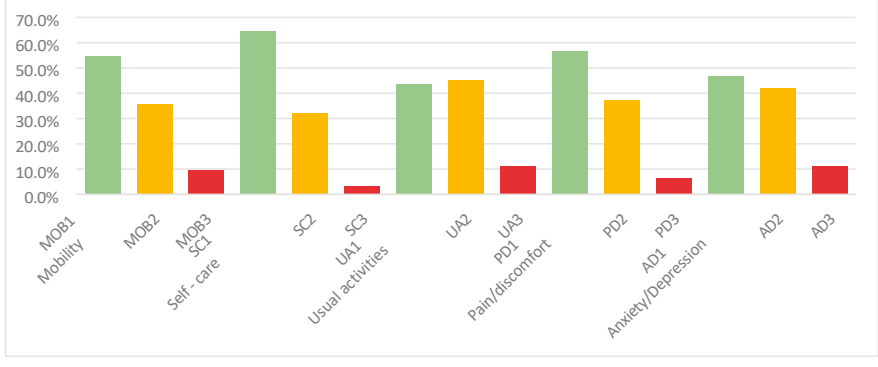


Figure 17 . Percentage distribution of problem levels upon self - assessment of the patients in all areas (metrics) on the day of admission

The subjective perception of patients for their health condition, indicated on the day of admission through VAS, assessed with average value 60 [IQR 39.75], as the assessment after VAS in patients after **EQ-5D-3L** without complaints is higher than those who report for problems (Table 23).

Table 23. Self-assessment for the health state after VAS on the admission day

Criterion	Level	N	Mean	SD	Median	IQR (Q1;Q3)	Min	Max	P (Mann Whitney U)
Self-assessment after VAS_on the day of admission	11111	13	67.1	25.7	75	37 (50;87)	10	97	0.05
	With problems	49	51.6	25.8	50	31 (39;70)	0	90	

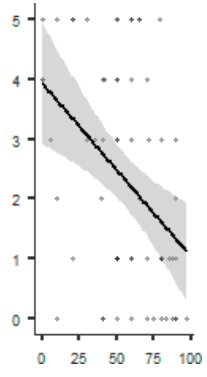


Figure 18. Correlation between the number of the involved metrics and VAS assessment

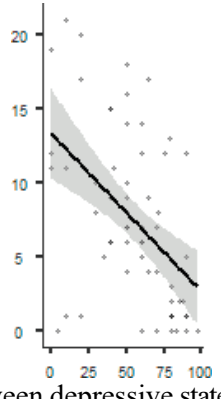


Figure 19 . Correlation between depressive state in hospital setting and VAS assessment

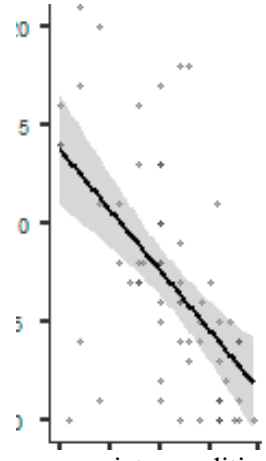


Figure 20. Correlation between anxiety condition in hospital conditions and VAS assessment

Upon hospital discharge, 43.5% (n = 27) of patients reported no difficulties (problems) in any of the EQ-5D metrics, and 56.5% (n = 35) indicated difficulties ($\chi^2 = 1.03$, $p = 0.310$). Observed is some growth in the number of the patients to level health profile - "11111" from 21% to 43.5 % (χ^2 (McNemar's test) = 10.9, $p \leq .001$).

The number of the affected metrics (from 0 to five) is indicated in Table 24.

Table 24. Distribution by number and share of the patients according to the number of affected areas upon discharge

Metrics, affected in patients	Number	%	p (χ^2)
Without difficulties	27	43.6%	
In one area	8	12.9%	
In two areas	13	21.0%	
In three areas	4	6.5%	<.001
In four areas	8	12.9%	
In all areas	2	3.2%	
Total	62	100.0%	

Significantly reduced is the number of patients with complaints in the 5 areas from 19.4% to 3.2%

From 24.2% of the patients with serious problems in one or more metrics upon admission only 3.2 % (n = 2) were discharged with 3 levels of self-assessment.

Positive moderate relationships are kept between the number of involved metrics and the level of anxiety (Spearman's ρ = 0.4035, p < .001) and level of depressive state (Spearman's ρ = 0.455, p = .001) upon discharge.

No one from the patients upon discharge does not report for extremely severe pain or discomfort and extreme anxiety/depression. The distribution of the levels of problems upon self-assessment of the patients in all areas (metrics) upon discharge is presented in Table 25 and Figure 21.

Table 25. Distribution of the levels of problems upon self-assessment of patients in all areas (metrics) upon discharge

Metrics in EQ-5D- 3L	Level	Number	%	Total	p (χ2)
Mobility	MOB1	47	75.8%	62	<.001
	MOB2	14	22.6%		
	MOB3	1	1.6%		
Self-care	SC1	51	82.3%	62	<.001
	SC2	9	14.5%		
	SC3	2	3.2%		
Usual activities	UA1	41	66.1%	62	0.001
	UA2	20	32.3%		
	UA3	1	1.6%		
Pain / discomfort	PD1	44	71.0%	62	<.001
	PD2	18	29.0%		
Anxiety / depression	AD1	39	62.9%	62	0.042
	AD2	23	37.1%		

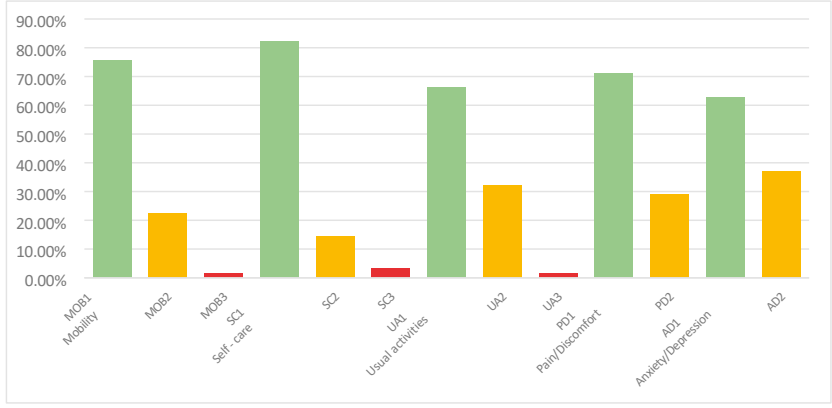


Figure 21. Percentage distribution of the levels of problems in patient self-assessment in all areas (metrics) upon discharge

Upon assessment of mobility, 53.6 % (n = 15) of the patients having reported difficulties during hospitalization, a positive dynamic was observed up to the MOB1 level, 46.4% were without changes (Table 26).

Table 26. Assessment of mobility on the day of admission and discharge

Mobility	Upon discharge				Total (n, %)		p (McNemar)
On the day of admission	MOB1 (n, %)		MOB2/3 (n, %)				
MOB1	32	94.1%	2	5.9%	34	100.00%	0.004
MOB2/3	15	53.6%	13	46.4%	28	100.00%	
Total	47	75.8%	15	24.2%	62	100.00%	

Table 27 presents comparison of the number of admitted and discharged patients with different levels on self-care. Upon admission without mobility problems (SC1) there were 40 patients, and with problems (SC2 and SC3, on the table we unite them under SC2/3) there were 22 patients admitted. Upon discharge, from the 40 persons with SC1 one pointed out of having aggravated, and from the 22 who were admitted with SC2/3, 12 patients indicated SC1 (ie, improvement). These 12 are 54.5 % of the total of 22 with problems in self-care.

Table 27. Assessment on self -care upon admission and discharge

Self- care	Upon discharge				Total (n, %)		p (McNemar)
On the day of admission	SC1 (n, %)		SC2/3 (n, %)				
SC1	39	97.5%	1	2.5%	40	100.00%	0.006
SC2/3	12	54.5%	10	45.5%	22	100.00%	
Total	51	82.3%	11	17.7%	62	100.00%	

Out of a total of 35 patients who were admitted with problems in performing their usual activities, upon discharge 16 of them (45.7%) improved, in 19 of the total of admitted patients no change is reported in this measure (Table 28).

Table 28 . Assessment of usual activities upon admission and discharge

Usual activities	At writing				Total (n.%)		p (McNemar)
On the day of admission	UA1 (n, %)		UA2/3 (n, %)				
SC1	25	92.6%	2	7.4%	27	100.00%	0.002
SC2/3	16	45.7%	19	54.3%	35	100.00%	
Total	41	66.1%	21	33.9%	62	100.00%	

From a total of 27 patients, who were admitted with pain/discomfort, upon discharge 11 of them (40.7%) improved, at 16 from the total number of admitted patients no change is reported in this measure (Table 29).

Table 29. Assessment of pain/discomfort upon admission and discharge

Pain/Discomfort	PD2/3 (n,%)				Total (n.%)		p (McNemar)
On the day of admission	PD1 (n.%)		PD2/3 (n,%)				
PD1	33	94.3%	2	5.7%	35	100.00%	0.027
PD2/3	11	40.7%	16	59.3%	27	100.00%	
Total	44	71.0%	18	29.0%	62	100.00%	

Out of a total of 33 patients who were admitted with symptoms of anxiety/depression, 15 of them (45.5%) improved upon discharge, with 18 of the total number of admitted patients no change is reported in this measure (Table 30).

Table 30. Assessment of anxiety/depression upon admission and discharge

Anxiety/Depression	Upon discharge				Total (n.%)		p (McNemar)
On the day of admission	AD1 (n.%)		AD2/3 (n,%)				
AD1	24	82.8%	5	17.2%	29	100.00%	0.044
AD2/3	15	45.5%	18	54.5%	33	100.00%	
Total	39	62.9%	23	37.1%	62	100.00%	

The subjective perception of the patients for their health state indicated upon discharge through VAS evaluated with mean value 80 [IQR 20.00], as a VAS assessment in patients after **EQ-5D-3L** with no complaints is higher than those who reported for problems (Table 31).

Table 31. VAS Self-assessment upon discharge

Criterion	Level	N	Mean	SD	Median	IQR (Q1;Q3)	Min	Max	P (Mann Whitney U)
Self-assessment after VAS upon discharge	11111	27	87.4	14.5	90.0	20 [80;100]	40	100	<.001
	With problems	35	74.0	16.1	79.0	22.5 [64;100]	30	100	

The number of the areas marked as problematic positively correlates with the level of depressive (Spearman's $\rho = 0.455$, $p < .001$) and anxiety (Spearman's $\rho = 0.403$, $p < .001$) condition in hospital conditions with moderate character.

Observed is a negative moderate connection between depressive condition in hospital settings (Spearman's $\rho = –0.439$, $p < .001$), anxiety condition in hospital settings Spearman›s $\rho = –0.354$, $p < .005$) and the self-assessment after VAS.

5. DISCUSSION

Our survey is one of the few in the scientific literature in Bulgaria, which explores the effects of the early rehabilitation in patients with moderate and severe covid pneumonia, and its purpose is to suggest an early rehabilitation program for these patients.

Our results show that the combination of respiratory rehabilitation and medical treatment decreases the symptoms of dyspnea, improves physical capacity, reduces anxiety levels and depression and increases the assessment of the patients for their own health condition. The methods we used are affordable, easy to use and safe for patients and should be included in treatment protocols for the treatment of patients with COVID-19 from the first day of their admission. Our data are consistent with literature data that emphasize the real effectiveness of physical therapy in reducing oxygen needs in patients with respiratory system diseases, admitted in hospital [37]. As stated in literature, in seriously ill patients rehabilitation should start early, encouraging, as soon as possible, physical activity together with posture and breathing control [Agostini F et al., 202]. Many studies report that rehabilitation in the acute phase would be useful for mitigation of the consequences from covid, which suggests, that early mobilization improves respiratory function and supports the levels of saturation with oxygen [Zhao HM et al., 2020], [Aytur YK et al., 2020]. For a large percentage of patients, physical therapy interventions carried out under control of treating specialists have been beneficial for their faster recovery and have contributed to increasing their confidence and improving their psycho-emotional condition. The application of rehabilitation in patients with severe form of COVID-19 would reduce the complications of the disease which also shows influence on the economic consequences from long- lasting disability among the working population [Maital S et al., 2020]. International guidelines for rehabilitation of persons with Covid with moderate and severe form of the disease recommend rehabilitation with breathing control exercises, exercises to facilitate expectoration, passive or active exercises depending on the patient's condition, to preserve the range of motion in the joints of the musculoskeletal system, stretching exercises, sitting and standing position exercises, balance exercises, walking and psychological support [Barker-Davies R et al., 2020], [Aytur YK et al., 2020]. The prescription for rehabilitation (type, duration, frequency of applied exercises) must be according to the individual condition of the patient, the severity of the disease and the presence of accompanying diseases. Most of the authors offer different protocols, but most often they have a duration between 15–40 min., once up to twice daily [Wasilewski MB, et.al., 2021].

The multicenter prospective cohort study of Berentschot and collaborators includes groups of patients, having undergone respiratory rehabilitation, and persons who had not had such. The results from the study show that the patients who underwent rehabilitation improved the function of their cardiovascular and respiratory system, muscle strength and mobility, while in patients without rehabilitation an improvement was reported only in muscle strength [Berentschot JC et al., 2022].

We compared part of the data of the persons we studied (indicators from BGA and flow rate of oxygen therapy) through a retrospective analysis with the data of patients, who had not undergone respiratory rehabilitation. For ethical reasons, we did not use a standard control group, but rather a control group. This comparison gave us the opportunity to analyze the data related to the changes in the gas exchange of the surveyed subjects during the rehabilitation of the patients.

An advantage of this study is the impact on the quality of life of patients with COVID-19 in the period of hospitalization. The health insurance fund must focus on the assessment of the needs of the patients and the application of effective strategies for quantification of the quality of life of patients after COVID-19 who did or did not have physical therapy. Nandasena et al. in 2022 published a study to assess the quality of life after COVID-19 in patients, which shows that this indicator is deeply affected regardless of the time elapsed after discharge or recovery. They show that older patients with different impairments had a significant reduction in quality of life.

More studies are needed to investigate not only the effect of physical therapy on the clinical manifestation of the disease, but also on the physical capacity, muscular strength and lung function.

We believe that the application of physiotherapy in the treatment of this category of patients can be considered an interesting therapeutic

tool, which can be applied after thorough assessment of each patient's abilities, needs and co-morbidities.

Especially in countries with a high prevalence of SARS-CoV-2 and subsequent number patients with temporary pulmonary impairment physical therapy can be a cost-effective option capable of reducing respiratory symptoms, preserving or improving lung function and decrease both the short term and the long term complications of the disease. Respiratory exercises and etc. kinds of physical therapies conducted in the acute phase of this illness can represent a promising therapeutic strategy for dealing with the most troubling symptoms of COVID-19 (like cough and dyspnea). Moreover, the findings of the present study can be used by researchers and clinicians for better understanding and coping with disabilities and rehabilitation needs of patients with COVID-19.

5.1. Assessment on demographically data from the survey

In our study no statistically significant difference was found in the distribution by gender at age up to 60 years and over 61 years in the control and the experimental groups. I.e. concerning the gender, the groups are uniform. Statistically significant difference in age in men and women up to 60 years and women over 61 years in the control and surveyed group was also not reported. A difference was noted only in the age of men over 61 between the two groups.

Pijls BG and collaborators [Pijls BG et al., 2021] performed a meta-analysis of 59 studies including 36,470 patients, which showed that men and patients aged 70 years and older have a higher risk of infection with COVID-19, severe illness, admission to intensive care unit and death. Men had a higher risk of infection with COVID-19, than women. When infected, they also had a higher risk of severe COVID- disease, higher need for intensive care and a higher risk of death. The analyzes of the data from cohort studies also show that patients aged 70 years and older have a higher risk of infection, a higher risk of severe COVID-19 disease, a higher need for intensive care and a higher risk of death after contamination in comparison with patients under the age of 70 [Pijls BG et al., 2021].

5.2. Assessment on accompanying diseases

The data from our study point that the prevailing accompanying

disease for the patients is arterial hypertension. The share of patients in the group studied by us who have accompanying cardiovascular diseases is higher, compared to endocrine, metabolic and other diseases. Regarding co-morbidities, a relatively even distribution was observed in the same age groups. Exceptions are endocrine and metabolic diseases, which are more often registered in the control group in patients aged over 61 years – 13 (43.3%) from the whole subgroup, while in the experimental one there were 3 (13%) patients with similar diseases. The accompanying diseases, mostly cardiovascular, are more often found in older patients. In our research hypertension was registered in 82.6% of all patients over 61 years in the work group, and in 70 % of the adult patients in the control group. Co-morbidity is also more pronounced in the subgroups of patients aged over 61 years. Only 4 (13.3%) adult patients from the control group and 2 (8.7%) patients from the work group do not report for accompanying diseases.

Ours data can be matched with latest studies which point that arterial hypertension represents one of the most common comorbidities in patients with COVID-19. This prevalence varies between 10% and 34% [Tadic M et al., 2020]. There are a few studies which explore the influence of concomitant diseases on the outcome for these patients with contradictory results. Hypertension has been shown to be more prevalent in patients with an unfavorable outcome (ICU admission, use of mechanical ventilation, or death).

Li et al. summarize the findings of 6 studies and show that the prevalence of hypertension, cardiac and cerebrovascular diseases and diabetes in patients with COVID-19 was 17.1%, 16.4% and 9.7%, respectively. [Li B et al., 2020]. The cases on hypertension, cardiovascular diseases and diabetes are two to three times higher in patients with severe type of COVID-19, than in their non-severe analogues. Yang et al. include 46 248 patients with COVID-19 of 8 studies and report that the most common accompanying diseases are hypertension, diabetes, cardiovascular diseases and diseases of the respiratory system [Yang J et al., 2020].

Shalaeva and colleagues [Shalaeva et al., 2022] summarize results from a research, according to which hypertension by itself does not increase mortality from COVID-19 or the risk of hospitalization in

intensive care unit. Untreated patients with hypertension are exposed to promoted risk from hospital treatment. Without the usual accompanying diseases such as age, obesity, diabetes, myocardial infarction hypertension bears small or no risk for increase of mortality from SARS-CoV-2 infection.

5.3. Assessment of blood gas analysis parameter results upon comparing both groups of patients

Hypoxemia in patients with Covid-19 pneumonia is often subjectively unrecognized and due to this big part of the patients seek medical help late and enter for treatment with severe symptoms of respiratory deficiency and need for breathing support [Yang X et al., 2020]. Blood gas monitoring can help manage the disease, but in order to assess the need for application of methods for breathing support and for prediction of disease outcome [Lakhani J et al., 2019]

In connection with the need for more detailed description of the upcoming changes in the parameters of BGA, tailored with the age of the patients, the severity of the pneumonia and the length of hospital stay in the data analysis we divided the monitored patients into several subgroups. There are few studies that analyze data from parameters of blood gas analysis of persons in the acute stage of COVID-19, who undergo rehabilitation. The data from BGA of the subjects we examined we compared with those of patients corresponding to the inclusive criteria for our research, but who did not undergo rehabilitation.

5.3.1. Assessment of the results from KGA on the women from both groups of patients

Concerning the average value of pCO2 on the day of admission for women from the work group and for women from the control group, no statistically significant difference was observed. For average pCO2 values on the 3rd day ($b < 0.015$) and upon discharge ($r < 0.019$) this difference was significant, with pCO2 decreasing upon discharge. There was a non-significant increase in mean saturation value from 93.61 (±2.69) on the day of admission to 94.5 (±2.79) on the day of discharge for women in the RR group. No statistically significant difference was observed in women in the indicator for saturation upon admission, discharge and difference in saturation (discharge - hospitalization).

5.3.2. Assessment of the results from BGA for the men from both groups of patients

Although no statistically significant difference was reported upon comparing pO2 on the day of discharge between men from the two groups, as to the pO2 difference indicator (discharge and hospitalization) statistically significant dependence was observed in favor of the studied group ($p < 0.019$). Regarding pCO2 upon admission ($p < 0.001$) and discharge ($p < 0.005$) a statistically significant difference was reported between male gender subjects in both groups and reduction of the pCO2 indicator upon discharge. The average value of the saturation on the day of admission is 92.67 (±3.2) and on the day of discharge is 94.76 (±2.35) for the men in the RR group. A statistically significant difference was observed in the saturation difference indicator (discharge - hospitalization) in men from both groups ($p < 0.020$).

5.3.3. Assessment of the indicators from blood gas analysis between persons in the age group up to 60 years for the surveyed and the control group

No statistically significant difference was reported upon comparing of PH, pO2 on the day of discharge between the patients aged up to 60 y. from the patients who performed breathing exercises and the control group, as well as for the sign for difference in pO2 (discharge and hospitalization). Regarding pCO2 upon admission ($p < 0.015$) and discharge ($p < 0.004$) statistically significant difference was reported between the persons aged up to 60 years in both groups and reduction in the indicator for pCO2 upon discharge. No statistically significant difference was reported in the indicators for saturation upon admission, upon discharge and difference in saturation (discharge - hospitalization) in patients up to 60 years between the two groups.

5.3.4. Assessment on the indicators from blood gas analysis between individuals in the age group > 61 years for the study and control groups

In the group of patients aged over 61 years pCO2 is higher in the

studied group both upon admission and upon discharge, which is explained with accompanying diseases of the same. The monitored pO2 parameters in the group over 61 years did not show statistically significant difference both upon admission and upon discharge. While in patients aged up to 60 years, although the targeted parameter has no statistically significant difference, it has a better value in the experimental group.

5.3.5. Assessment of the indicators from blood gas analysis in the patients with severe pneumonia from the studied and the control group

From indicators on blood gas analysis in the studied group upon admission and discharge it follows that pO2 and saturation have reliably improved ($p < 0.05$), as the saturation reached the normal values. These data are consistent with the data from the study by Kovlen et al. who make a comparison between group of patients with severe covid-pneumonia undergoing rehabilitation, and a control group. Based on the results from the analysis on the dynamics of the separate metrics, observed at the beginning and at the end of rehabilitation of patients in hospital conditions, they report normalization of the indices of saturation in the blood in the group for comparison 92.03 ± 0.30 (90 – 96%) to 96.76 ± 0.32 (93– 99%, $p < 0.05$) and in the group for monitoring from 92.78 ± 0.37 (90 – 97%) to 98.22 ± 0.23 (96 – 100%, $p < 0.05$) [Kovlen et al., 2022].

In the analysis of received results we found that the patients with severe pneumonia from the studied group also showed statistically significant difference concerning the difference in pO2 (discharge – hospitalization) in comparison with the control group ($p < 0.048$). These values could be explained with the more dynamic recovery of the patients who underwent respiratory rehabilitation, in comparison with the control group. In patients with hospital stay up to 10 days a positive effect is reported in terms of pO2 recovery to normal values, while in the patients with prolonged hospital stay the dynamics of the upcoming changes is less significant.

This finds explanation in the fact that the patients with short hospital stay are in a more preserved general condition since the beginning of hospitalization and their indicators have better values. While patients with a long stay are in a worse general condition and the reverse course of the disease is delayed. However, we did not find any similar differences when comparing the results from the control and the studied group in terms of gender, age and stay over 10 days.

It should be noted that upon admission, the average pH of the patients is reported in reference values and does not suffer significant changes.

Concerning the tracking of the parameter of pCO2 results obtained when comparing both groups have no statistical significance. The data from our study approach these in the research of Sanghani [Sanghani H. et al., 2022], according to whom patients with severe COVID-19 show higher PH values and lower pCO2, or respiratory alkalosis in 50% of the cases. There are different theories for the occurrence of respiratory alkalosis in severe pneumonia. It is usually caused by a process involving hypoxia-induced hyperventilation, lung diseases, and central nervous system diseases [Alfano G, et al., 2022]. The virus causing COVID-19 demonstrates affinity for angiotensin-converting enzyme 2 receptors, therefore ACE2 receptors in the carotid body in the area of the bifurcation of the carotid artery, and this tropism can be a possible mechanism for this process [Jubran A 2015]. In our research, similar to the survey of Sanghani, 50% of the patients had a pH value above the upper limit and pCO2 below the lower limit of the reference values for these indicators.

5.4. Assessment of the results in patients from the surveyed group before and after rehabilitation

5.4.1. Assessment of the results from BGA in patients of the studied group before and after rehabilitation

From indicators of blood gas analysis it follows that pO2 and the saturation have improved reliably ($p < 0.05$), with the saturation reaching the normal values.

It should be noted that upon admission, the patients' pH was reported in reference values and did not undergo significant changes.

Significantly improved were the pO2 values from 8.67 to 9.79 kPa ($p < 0.001$). The pCO2 value increases, but nevertheless remains within normal values.

5.4.2. Assessment of dyspnea symptom-related outcomes upon physical exertion (Borg scale) and physical capacity (30SCT) in the studied group of patients

5.4.2.1. Assessment of the results connected with symptom on shortness of breath during physical exertion (Borg scale) in the studied group of patients

Of all the symptoms accompanying the disease, caused of the new Sars-Cov-2 coronavirus, the most important and disturbing symptom for patients is the symptom of shortness of breath (dyspnea). Dyspnea is often associated with fear of death and leads to a significant reduction in the motor activity of affected individuals and a higher risk of developing complications, connected with continuous immobilization. Despite the wide-spread COVID-19 disease among the human population, the symptom of breath shortness in this severe course disease is relatively less prevalent compared to other coronaviruses, such as severe acute respiratory syndrome (SARS)-CoV or The Middle East respiratory syndrome (MERS)-CoV [Zhu Z et al., 2020]. A systematic review and meta-analysis Rodriguez-Morales and collaborators [Rodriguez-Morales AJ et al., 2020] establishes dyspnea in 45.6% (95% CI: 10.9–80.4%). In another study by Li and collaborators [Li LQ et al., 2020], including the data of 1994 patients, the common percentage of the patients with breath shortness is 21.9%. The variations between the separate studies can be explained with the differences in the manner in which the symptom of dyspnea was investigated and documented.

The mean value by the modified Borg scale for patients from our study it was under 3 before the beginning of the survey i.e. under the moderate degree for dyspnea upon physical exertion. The degree of dyspnea was measured after making 30SCT, three times, before the start of the rehabilitation program, on the third day and on the day of discharge from the hospital ward.

In our study, the dyspnea score on the modified Borg scale ranged from 0 to 10, with a mean of 2 (0.5; 5).

The results of our research show a significant reduction of the subjective assessment on tolerance to exertion after the modified on Borg scale in the studied group after rehabilitation (average from 2 (0.5; 5) to 0 (0; 0.75), which shows general improvement of patients' physical health after rehabilitation, expressed in improved function of the cardiovascular and respiratory systems and tolerance to physical exertion. Our results can be matched as approaching the results of Filipovic and collaborators [Filipović T et al., 2023]. In a prospective observational study for respiratory rehabilitation in the acute stage of COVID-19, including 147 patients with moderate and severe course of the disease a statistically significant reduction was found in the degree of shortness of breath according to the modified Borg scale. With values upon admission from 2.52±0.6 for the group of patients with moderate severity of the disease after undergoing rehabilitation program, an mean value of 0.52±0.51 is reported after the modified Borg scale. Analogous is the result for the group of patients with severe pneumonia, in which the values for the degree of dyspnea according to Borg changed from 3.62±0.65 to 1.58±0.58.

The intensity of the rehabilitation program must be adapted to the patient's abilities in order to be safe and secure for them. This is the reason why a large number of studies recommend low-intensity training for patients tested after the Borg scale for dyspnea <3 [Vitacca M et al., 2020]. A retrospective descriptive cohort study of Piquet and associates [Piquet V, et al., 202] for patients who underwent respiratory rehabilitation reported a 30% improvement in dyspnea as measured by the modified Borg scale after conducted STS test in the end of the rehabilitation program.

5.4.2.2. *Assessment of the results connected with physical capacity (30SCT)*

Complications after moderate to severe infection with Sars-Cov-2 result from affecting the cardiovascular and respiratory system, related with systemic inflammation and continuous immobilization [Salman et al., 2021]. To start a rehabilitation program for patients with moderate to severe coronavirus disease (Covid-19) it is necessary to assess the physical capacity, which determines the degree of impairment of the muscular function and the ability to perform daily activities.

To investigate physical capacity, we applied the 30SCT test. He is easy for performance and is with comparatively good informativeness. Conducting this test is preferable as it doesn't cause considerable fatigue, requires little space, can be applied in isolation conditions, and has a short duration. 30STS is approaching to 6-minute walking test (6MWT) when making the assessment of physical capacity [Gurses et.al., 2018]. In the clinic, the 30STS is commonly used as an indicator of balance and muscle strength of the lower extremities, especially in older patients with chronic diseases and immobilized patients, and is strongly related to function of the cardiovascular system in the elderly [McAllister LS, Palombaro KM, 2020]. A lower 30STS score indicates impaired cardiovascular function and a higher risk of falls and mortality. Given the general impaired condition of the patients, as well as the high levels of anxiety, some of them refused to undergo this test both upon admission and upon discharge. In 41 of the patients, we performed physical capacity follow-up by 30SCT. The result from 30 STS was calculated on the basis of the number of standings up from sitting position completed within 30 seconds. A higher result of 30STS shows better function of the lower extremities. We analysed the results in that part of the patients to whom the test was applied. Before the rehabilitation program, the patients in our study performed an average of 10 standings from sitting position. Neither of the participants in the survey did develop oxygen desaturation or elevated cardiac frequency and no fall accidents occurred. The data from our study can be compared with the data from the survey on Hidayati and collaborators for patients with moderate severity of Covid-19, who carried out average 13 uprights from sitting position within 30 seconds [Hidayati et al., 2021]. We encountered no significant difficulties during the test. The 30STS may be easier to perform than 6MWT for patients with COVID-19 treated in an isolation unit because it requires only a little space. In compliance with previous studies we found that 30 STS is simple, easy and safe for patients with moderate to severe COVID-19 who start to recover their motor function activity and activities from everyday life [YangLL, YangT, 2020]. When

assessing tolerance to physical exertion, we observed a statistically significant increase in the results of 30SCT in the group we studied, than before the rehabilitation average from 10 (3; 13) to 12 (7; 15) times, which shows raising of the tolerance to physical activity, improving the state of the cardiorespiratory system and increasing endurance. We established a positive influence of the applied complex of breathing exercises on the physical capabilities of the patients. Although they failed to reach the norm. This is explained with the severe course of the disease and the protracted recovery of the physical capacity, which is also confirmed by other sources, having carried out study in this direction. Our study showed that patients with moderate and severe COVID-19 had a lower 30STS score compared to the healthy elderly population [Whitney et al., 2005]. Insufficient recovery of physical capacity on the day of discharge is also an indicator for the need for conducting rehabilitation in the conditions of specialized hospital or in home conditions for patients who survived covid-19 pneumonia. In a systematic review of studies for rehabilitation of patients with COVID-19 by Halabchi et al. [Halabchi et al., 2022], including 9 interventional and 14 observational studies, the results reported showed comprehensive effect on respiratory rehabilitation on the physical capacity, respiratory function as well as psychological aspects. Six minutes walking test (6MWT) and 30STS are the most common tests used to assess physical capacity in included studies. The results show a significant improvement in favor of the patients undergoing rehabilitation.

In the study by Puchner et al. patients discharged after a severe course of COVID-19, often had persistent physical dysfunctions after being discharged from the hospital, tracked through the 6-minute walking test. These patients benefit significantly from multidisciplinary inpatient rehabilitation. 57% of all patients with COVID-19 had pathological indicators from spirometry, and all participants in the survey had still impairment of the pulmonary diffusion test at the end of the rehabilitation program [Puchner B et al., 2021]. Although the physical activity test cited above is different from applications from the 30 sec test we applied, as it concerns tracking one and the same metric, we think an analogy can be made on obtained results. As evident from the Puchner et al. study, the patients monitored by him in the end of the study period still had a decrease in their physical capacity.

5.4.3. Assessment of the effect from the quality of life related rehabilitation program (EQ-5D-3L)

Patients with Covid-19 pneumonia suffer from pain and discomfort, who limit to a significant extent the daily life activities and in case of more severe course flow significantly decrease their capabilities for self-care. Just because of this fact, it is extremely important, not only to make a clinical assessment of the disease, but to focus attention on the personal side of the disease, namely the patient's quality of life. There are many tools available to measure health status and quality of life from the patient's perspective in people with lung disease. In our study, we applied the EQ-5D-3L questionnaire, which is short and easy to apply and one of the most preferred questionnaires in this field [Pancera S et al., 2021].

From an analysis of the reported results in the experimental group, we found that that the attached rehabilitative program has a good corrective impact on the quality of life. When entering the hospital, 79% of the examined persons indicated difficulties. Upon discharge from the ward, 43.5% of the patients reported no problems in any of the EQ-5D metrics, and 56.5% reported difficulties. We observed some growth in the number of the patients without health problems, from 21 to 43.5%. We also reported a permanent reduction in complaints in each of the used metrics after EQ-5D and increase in the motor activity and independence in everyday life. In the correlation analysis made between the results of the number of affected metrics in a test and HADS and the perception of health status according to VAS, a negative moderate relationship was observed. Available is an inversely proportional dependency, i.e. with a decrease in the levels of the targeted indicators, the self-assessment of patients' health status logically increases. The results we obtained can be compared with the results of Hayden MC and collaborators, [Hayden MC et al., 2021], who used the EQ-5D-5L to study the health status of the patients having survived coronavirus infection, as an assessment of the performed respiratory rehabilitation. The EQ-5D 5-level version (EQ-5D-5L) was introduced by EuroQol Group in 2009 to improve the sensitivity of the instrument compared to the EQ-5D-3L we used. This prospective observational study of 108 patients was conducted at Bad Reichenhall Clinic, Germany, an inpatient respiratory rehabilitation center for adult patients. The authors report significant improvement in all metrics of the test. This is the second published and biggest research, conducted in Germany, to analyze the safety, feasibility and efficacy of a three-week inpatient respiratory program for patients who are

were admitted due to persistent symptoms after experiencing acute COVID-19 [Hayden MC et al., 2021]. In terms of overall subjective current health status, data from the German research revealed a significant improvement, with large scale of the effect for all patient groups. Three-quarters of patients achieved an improvement in the VAS score, as well as a significant reduction of depression and especially anxiety in all subgroups. Demeco and associates [Demeco A et al., 2020] recommend rehabilitation programs after COVID-19 not only for physical reasons, but also for psychological reasons.

The data of our study are similar to those of Kovlen and collaborators' study when analysing the quality of life of patients, having experienced COVID-19. According to the questionnaire EQ5D the patients in both groups report for improved health and quality of life. In patients of the group for monitoring the values before and after treatment were 1.48 ± 0.18 and 1.12 ± 0.14, respectively ($p < 0.05$). In the comparison group, the values before and after treatment were 1.76 ± 0.23 and 1.18 ± 0.13, respectively ($p<0.05$)) [Kovlen et al., 2022].

Another study that comes close to our study in terms of results by attitude on health status and quality of life, is by Izzo R. et al. In the analysis of data of patients with severe course of covid-19, who conduct rehabilitation in hospital conditions, Italian scientists report an improvement in the quality of life, statistically significant increase from admission to discharge ($p< 0.001$) in percents of persons who answer "no problem" for each parameter (mobility, self-care, usual activities, pain/discomfort, anxiety/depression), which shows global improvement in patients' quality of life [Izzo, Rosanna et al., 2022].

5.4.4. Assessment of the effect of the conducted rehabilitation program regarding the psycho-emotional state of the patients in the experimental group (HADS)

Each disease affects the behavior and emotions of patients. Patients with COVID-19 experience different levels of pain, discomfort, limitation and disruption of activities of daily living, which significantly impairs their quality of life. These disorders are directly reflected in behavioral patterns and their psycho-emotional state. From the conducted research, we found that along with the changes in the objective status, the majority of patients report changes in their

psycho-emotional state, manifesting in anxiety, fear of the future, reduced motivation to maintain a good appearance etc. This necessitates the use of a dynamic tracking tool for the psychological status before and after conducted treatment. For assessment of the psychoemotional status we applied test HADS [Zigmond and Snaith, 1983]. In the analysis of the reported results, a significant corrective influence of the applied rehabilitation program is reported in the studied group in relation to the tracked indicators for the psycho-emotional state of patients. In the correlational analysis made between the results from the HADS questionnaire and the perception of health status after VAS a negative moderate relationship is observed. These results testify that the rehabilitation program has a psychocorrective influence manifesting in lowering the main indicators of anxiety and depression from the test applied by us. Our results, connected with the positive influence of RR on the psycho-emotional state of patients with COVID-19, can also be compared with the study conducted by Chikhanie et al. in France. French specialists conduct a prospective cohort study, which includes patients having undergone respiratory rehabilitation in the period from 2019 to 2022 after a stay in intensive care unit. The aim of this study is to evaluate the impact of RR in severe COVID-19 patients and to compare their outcomes with those of other patients, who were rehabilitated after being admitted in intensive care unit due to respiratory deficiency for other reasons [Chikhanie et al., 2021]. Significant and rapid recovery was observed in patients with COVID-19 both in the muscular strength, and on mental status, objectified by the Hospital Anxiety and Depression Scale (HADS), compared to patients with COVID-19 rehabilitated after being admitted in intensive care unit. These observations suggest that RR may limit PTSD for those patients. The observations of Chikhanie et al. are also associated with significant residual physical and psychosocial disability, which probably requires longer rehabilitation. The team of French researchers recommends early start of RR in the intensive care unit or the pulmonary diseases unit. More controlled and long term studies are needed for better understanding the role of RR after COVID-19. While the survey of Chikhanie et al. [Chikhanie et al., 2021] found a significant improvement regarding anxiety and depression assessed using the HADS, Hermann et al. (0.5; 5) (0.5; 5) [Hermann et al, 2020] and Spielmanns et al [Spielmanns et al., 2021] did not report significant improvements.

A recent interventional cohort study by Bompani [Bompani N, et al., 2023] and al. for patients with severe COVID-19 in the acute stage of the disease and undergone rehabilitation, including respiratory exercises, exercises for preserving the volume of movement in the joints and psychological support, reports positive change in HADS anxiety and depression scores.

Limits on the present one survey

The present survey has several limitations, one of which is represented by the small number of participants. Assessment of lung function through spirometry during the survey was not possible because this type of survey was not allowed to be conducted in patients infected with SARS-CoV-2.

The control group used in this survey was only tentatively suitable for making an adequate comparison. Direct comparison concerning EQ-5D-3L, HADS, 30 STS, Borg scale cannot be done because of the retrospective data collection and the resulting missing data for the control group. We cannot precisely distinguish the influence of specific breathing exercises from the outcome of the whole therapeutic plan. This survey provides only data on the immediate effect of respiratory rehabilitation, it cannot yield long term results. Long- term monitoring of patients, having survived COVID-19, reporting of the quality of life and the long term benefits from the rehabilitation will have to be provided by future surveys.

6. CONCLUSION

Physical therapy may represent a cost-effective option, especially in countries with a high prevalence of SARS-CoV-2 and a large number of patients with temporary pulmonary impairment, capable to reduce the respiratory symptoms, preserve or improve lung function and decrease both short term and long term complications. Respiratory exercises and other kinds of physiotherapy, conducted in the acute phase of this disease, may represent a promising therapeutic strategy to improve the physical condition of these patients and address the most worrisome symptoms of COVID-19 (such as cough and shortness of breath). Moreover, the findings of the present study can be used by researchers and clinicians for the better understanding and coping with disabilities and the needs for rehabilitation of patients with COVID-19.

Given some limitations of our survey, we believe that more researches are needed to analyze the ongoing symptoms in patients who survived COVID-19, the long-term effects of the applied rehabilitation and the conduct of rehabilitation in domestic and ambulatory conditions. On the base on already known surveys for telerehabilitation and their proven efficiency we can also offer this modern method in the future as an integral concept for tracking patients who have recovered from the new coronavirus.

We believe that the application of rehabilitation in the treatment of this category of patients can be considered an interesting therapeutic tool that can be applied after a thorough assessment of each patient's abilities, needs and co-morbidities.

We report the need for a generally valid standard, which would be a potential option for physiotherapy treatment.

Intensive treatment is not a part of the main professional training in physiotherapy and is not part of the specialization curriculum. There is a need to increase the qualification of medical specialists by conducting additional postgraduate courses for training in physiotherapy for physiotherapy specialists, rehabilitators and kinesitherapists who to be used in intensive care medicine.

7. ALGORITHM FOR REHABILITATION OF PATIENTS WITH COVID-19 PNEUMONIA IN THE ACUTE PHASE OF THE DISEASE

7.1. Examination of a patient

- Medical history: complaints from the type of cough, shortness of breath, tiredness, pain symptoms, restriction in the everyday activities; accompanying and past diseases, allergies, etc.
- Somatic status
- Tests – laboratory tests (blood count, BGA, C-reactive protein, D-dimer), imaging tets (X-ray, CT).
- Functional status:
  - Determining the physical capacity through 30STS
  - determining of symptoms: degree of shortness of breath using the modified Borg scale upon physical exertion. Done after conducting 30STS.
- Quality of life and psycho-emotional status:
  - determining the quality of life through EQ-5D- 5L;
  - determining the psycho-emotional status through Hospital Anxiety and Depression Scale (HADS).

7.2. Goal and tasks of the rehabilitation program

The goal of the rehabilitation program in the acute stage is optimal functional recovery of patients with Covid-19.

The tasks are connected with improvement of pulmonary function and affecting the symptoms of dyspnea and cough.

The rehabilitation of patients in the acute phase that we applied to the patients in our survey is easy to perform, safe and applicable to patients with moderate or severe course of the disease.

The program for respiratory rehabilitation includes changes in the body position, which optimize ventilation and improve gas exchange, passing through the lateral, half-bed position and prone position. The plan for RR also includes techniques for breathing with active breathing

cycle, for control of the shortness of breath, slow exhaling techniques for patients, who do not develop desaturation, and techniques, which decrease the respiratory rate.

Positions and respiratory exercises:

The patients need to be advised to change the positions of their body every two hours during the day, going through prone, semi-lying and side-lying position.

(P1) starting position: supine with head on the pillow at an angle of 45 degrees to the surface of the bed/side lying with elevation of the upper part of the body, control of breathing (ACBT); purpose: facilitating breathing;

(P2) starting position: raising the upper body at an angle of 45 degrees, placing pillows under the armpits on both sides, placing a pillow under the knees, breathing control (ACBT); purpose: to facilitate breathing by reducing heaviness of the upper limbs;

(P3) starting position: position at 135 degrees in an incomplete prone position with the body turned slightly to the side, a pillow is placed under the head and a blanket in front of the abdomen, calm and even inhalation/exhalation. Duration: individual tolerability, up to 2 hours; purpose: better ventilation of the posterior lung departments;

(P4) starting position: prone position with a small pillow under the abdomen/pelvis and hands under the forehead, calm and even inhalation/exhalation. Duration: individual tolerance, up to 2 hours; purpose: better ventilation of the posterior lung departments;

(P5) starting position: knee-elbow position with the head resting on the hands or the mattress of the bed, calm and even inhalation/exhalation; purpose: better ventilation of the dorsal lung departments;

(P6) starting position: by choice, sitting on the edge of the bed/or sitting on a chair/or sitting on a chair with stepping over and carrying the upper part of the body, calm and even inhalation/exhalation; purpose: better ventilation of the dorsal lung departments, facilitating breathing;

(P7) starting position: upright standing position with support of the hands on the knees /or with hands, leaning back on the wall taking easy and even inhalation/exhalation; purpose: to facilitate breathing by relieving the heaviness of the shoulder girdle.

Breathing with pursed lips: starting position: sitting position, shoulder and neck muscles are relaxed. The patient inhales slowly through the nose

for two seconds, holding the mouth closed, but breathing normally. The patient must be notified that it is useful that they count alone: inhaling - one, two. They should then "purse" their lips as if they were mouth-whistling or gently blowing out a candle flame, then exhale slowly through the pursed lips, while counting to four. The exercise is performed with a progressive increase in duration, from 1 to 5 minutes, depending on the fatigue which can occur; purpose: makes it easier to breath, while helping respiratory airways to be held open using slight breathing resistance through pursed lips upon exhalation.

The active cycle of breathing techniques is related to the consecutive performance of slow and easy breathing (control of breathing), with subsequent deep breathing 3–5 times, again control on breathing and 2–3 times short and sharp exhalation (huff) at open mouth, which facilitates the excretion of secretions from the respiratory tract.

Patients should be instructed to change their position in bed frequently and to perform the Active Cycle of Breathing Techniques 1-2 times a day for about 10 minutes, according to individual tolerance.

ACTIVE CYCLE OF BREATHING TECHNIQUES (ACBT)

<table>
<tr><td colspan="2">Objectives: Calming of breathing. Improvement of the ventilation</td></tr>
<tr><td colspan="2">Execution:</td></tr>
<tr><td>Breathe slowly through the nose
▪ Relax the body and try to calm your breath.
▪ Repeat this exercise until you feel ready to start the cycle again
▪ Relax your shoulders, take a deep breath through the nose, holding your breath for 2–3 seconds in the end of breathing.
▪ After this exhale slowly and in a controlled manner.
▪ Repeat this exercise 3-5 times</td><td>Inhale normally
▪ Actively exhale continuously through open mouth.
▪ Imagine that you want to blur the mirror with your breath.
▪ Take another deep breath and exhale quickly and strongly through open mouth
▪ Repeat the exercise to the maximum 2 times in a row to avoid too much strain</td></tr>
<tr><td colspan="2">1. Concentrate yourself on breathing
2. Inhale and exhale deeply 3-5 times
3. Inhale / exhale normally
4. Concentrate yourself on your breathing / control your breathing
5. Take deep breaths >>> go back to step 1</td></tr>
<tr><td colspan="2">Hold on to point 1 and 2
▪ If you are out of breath
▪ When it becomes too tense
▪ When you have dry cough</td></tr>
</table>

POSITIONS AND BREATHING EXERCISES FOR IMPROVEMENT OF BREATHING IN PATIENTS WITH COVID-19

Purpose : Facilitation of breathing by lifting the upper part of the body	**Starting position:** • Slightly lift the upper part of the bed so that the upper part of the body is higher • Take a position on your back or to the side	**Perform an exercise:** an active cycle of breathing techniques (ACBT)		 
Objectives: Facilitating the act of breathing. It relieves the weight of the arm	**Starting position:** • Place the upper part of the bed high so that the upper body is slightly elevated • Place pillows under the armpits on both sides • Place pillows under your knees • If needed, have some help to take the position.	**Perform an exercise:** an active cycle of breathing techniques (ACBT)		

POSITIONS AND BREATHING EXERCISES FOR IMPROVEMENT OF BREATHING IN PATIENTS WITH COVID-19

Purpose: Better ventilation of the posterior lung departments Facilitating the function upon breathing	**Starting position:** • Semi-abdominal position, turn over slightly to the side (position of 135 deg.) • Place a pillow under the your head • Place a blanket in front of the stomach • Support your shoulder and stay in this position, until you feel good or change the position after 2 hours	Try to inhale and exhale calmly and evenly	Duration: individual tolerance, up to 2 hours	
Objectives : Better ventilation of the posterior lung compartments Improved oxygen exchange	Starting position: • Prone position. A small pillow under the abdomen / pelvis • Hands under the forehead • Tip: Breathe calmly and deeply regularly. Stay in this position while you feel good or change the position after 2 hours.	Try to inhale and exhale calmly and evenly	Duration: individual tolerance, up to 2 hours	

POSITIONS AND BREATHING EXERCISES FOR IMPROVEMENE OF BREATHING IN PATIENTS WITH COVID – 19

Purpose: Better ventilation of the dorsal areas of the lungs Facilitating the breathing function	**Starting position:** • Place your knees and forearms on the bed - Support your head on your hands or on the mattress of the bed	Try to inhale and exhale calmly and evenly	Duration: individual tolerance	
Purposes: Improves ventilation of the dorsal areas of the lungs. Facilitating the work of breathing	**Starting position:** • Sit on the edge of the bed • Sit in a chair • Sit in a chair by stepping over it, transferring the weight of the upper body to the backrest	Try to inhale and exhale calmly and evenly	Duration: individual tolerance	

8. CONCLUSIONS

1. The data of our study give us reason to consider the effectiveness of the applied rehabilitation program in relation to the results of BGA in the group of patients with severe pneumonia (in the parameters for difference in pO2 discharge-hospitalization) and for men, in the indicator of difference in pO2 between the 1st and last day of hospital treatment, statistical significance was observed in favor of the surveyed group. In the remaining subgroups patients no statistically significant difference was reported between the researched and the control group concerning these indicators from the BGA.
2. The results research we conducted point for decrease of the subjective feeling for shortness of breath among the patients carried out rehabilitation in the acute phase of COVID-19.
3. We established positive influence of the applied complex of breathing exercises on the physical capacity of patients, although the 30STS threshold was not reached.
4. The persistent deficit in physical capacity even after discharge from the ward is indicative of the need for continued rehabilitation after acute period for patients with severe course of COVID-19.
5. We reported sustained reduction in the complaints in each of the EQ-5D health status test metrics used.
6. The results from the research with the hospital anxiety and depression scale (HADS) reported corrective influence of the applied rehabilitation program with a reduction in anxiety and depression indicators.
7. The rehabilitative program we suggested is safe and effective and easy to implement for patients in the acute phase of COVID-19.

9. CONTRIBUTIONS

Theoretical and methodological contributions:

1. Presented is the first survey in Bulgaria for efficiency of respiratory rehabilitation for patients with COVID-19 in the acute phase of the disease in a hospital setting
2. The need for an early start for rehabilitation has been proven for patients with moderate and severe course of the COVID-19 disease
3. Motivated is the implementation of subsequent physiotherapy interventions for patients, having survived severe COVID-19 pneumonia

Practical contributions:

1. For the first time in Bulgaria there has been introduced a structured program for rehabilitation of patients with moderate and severe course of pneumonia caused by COVID-19.
2. Created is an exemplary algorithm for rehabilitation of patients in the acute phase of COVID-19.

10. LIST OF PUBLICATIONS RELATED TO THE DISSERTATION

1. Dafina Bacheva, Principles of rehabilitation for patients with Covid-19 in an intensive care unit based on the Leuven protocol, Journal of Varna Medical College, vol. 6, 2023
2. Dafina Bacheva, Mariyana Mihaylova, PLACE OF KINESITH-ERAPY IN COMPLEX RESPIRATORY REHABILITATION, KNOWLEDGE – International Journal Vol. 45., 2021