ORIGINAL ARTICLE

Respiratory muscle strength, lung function and persistent symptoms of COVID-19 in hospitalized and non-hospitalized individuals one year after infection: a cross-sectional study

Força muscular respiratória, função pulmonar e sintomas persistentes um ano pós-COVID: um estudo transversal

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Abstract

Objective: to evaluate respiratory muscle strength, lung function, and persistent COVID-19 symptoms in hospitalized and non-hospitalized individuals one year after infection. **Methods**: a cross-sectional study included 160 participants (80 hospitalized, 80 non-hospitalized) in Fortaleza, Ceará (2021–2024). Assessments included manovacuometry, spirometry, and a questionnaire on persistent symptoms by organ system. **Results**: participants' mean age was 55.8 ± 15.87 years and BMI 28.85 ± 4.85 kg/m^2. Comorbidities were present in 37.5% of hospitalized participants, mainly cardiovascular diseases (27.5%). Persistent symptoms occurred in 42.5% of hospitalized and 45% of non-hospitalized individuals (p = 0.716). Fatigue was more frequent in non-hospitalized participants (42.5% vs. 16.2%, p = 0.032). Hospitalized individuals showed lower forced vital capacity (FVC) (60.01 ± 11.14%) compared to non-hospitalized (89.02 ± 10.94%, p = 0.021). Predictors of persistent symptoms included BMI (OR: 1.07, p = 0.001) and comorbidities (OR: 2.08, p = 0.040) in hospitalized participants, and acute-phase symptoms (OR: 4.05) and comorbidities (OR: 2.00) in non-hospitalized participants. **Conclusions:** one year post-infection, persistent symptoms were common, with fatigue predominating in non-hospitalized individuals. Hospitalized participants showed greater restrictive lung impairment. Predictors of prolonged symptoms differed between groups, highlighting the need for tailored follow-up strategies.

Keywords: COVID-19; Post-Acute COVID-19 Syndrome; Respiratory Function Tests.

Resumo

Objetivo: avaliar a força da musculatura respiratória, a função pulmonar e os sintomas persistentes da COVID-19 em indivíduos hospitalizados e não hospitalizados um ano após a infecção. **Métodos**: um estudo transversal incluiu 160 participantes (80 hospitalizados, 80 não hospitalizados) em Fortaleza, Ceará (2021–2024). As avaliações incluíram manovacuometria, espirometria e um questionário sobre sintomas persistentes por sistema orgânico. **Resultados:** a média de idade dos participantes foi de 55,8 ± 15,87 anos e o IMC de 28,85 ± 4,85 kg/m^2. Comorbidades estavam presentes em 37,5% dos participantes hospitalizados, principalmente doenças cardiovasculares (27,5%). Sintomas persistentes ocorreram em 42,5% dos indivíduos hospitalizados e 45% dos não hospitalizados (p = 0,716). A fadiga foi mais frequente nos participantes que não estavam hospitalizados (42,5% vs. 16,2%, p = 0,032). Indivíduos internados apresentaram menor capacidade vital forçada (CVF) (60,01 ± 11,14%) em comparação com os que não estavam (89,02 ± 10,94%, p = 0,021). Os preditores de sintomas persistentes incluíram IMC (OR: 1,07, p = 0,001) e comorbidades (OR: 2,08, p = 0,040) em participantes hospitalizados, e sintomas da fase aguda (OR: 4,05) e comorbidades (OR: 2,00) em participantes não hospitalizados. **Conclusões**: Um ano pós-infecção, os sintomas persistentes foram comuns, com a fadiga predominando em indivíduos não internados. Participantes hospitalizados apresentaram maior comprometimento pulmonar restritivo. Os preditores de sintomas prolongados diferiram entre os grupos, apontando a necessidade de estratégias de acompanhamento personalizadas.

Palavras-chave: COVID-19; Post-Acute COVID-19 Syndrome; Respiratory Function Tests.

INTRODUCTION

Since the emergence of coronavirus disease 2019 (COVID-19) in Wuhan, China, in 2019, the disease, caused by SARS-CoV-2, has resulted in more than 530 million infections globally[1]. SARS-CoV-2 belongs to a family of viruses that affect the respiratory tract, liver, central nervous system, and gastrointestinal tract in humans, and is not the first coronavirus to generate outbreaks, such as Middle East Respiratory Syndrome. (MERS-CoV) being an earlier example[2].

The COVID-19 pandemic was notable for its rapid spread, evidenced by the high transmissibility of the virus, which resulted in millions of infections and deaths worldwide[3]. The disease was initially treated as an acute condition, with an emphasis on immediate treatment and resuscitation to prevent mortality, using antivirals, immune modulators, and anti-inflammatory therapies, aiming to control the "cytokine storm" that can lead to multiple organ dysfunction syndrome (MODS)[4]. In Brazil, between 2020 and 2024, millions of hospitalizations due to Severe Acute Respiratory Syndrome (SARS) were recorded, with COVID-19 representing the majority of these

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hospitalizations and deaths[5]. However, the post-COVID condition, also called long COVID, has been a growing concern. It is characterized by the persistence of symptoms such as fatigue, shortness of breath, and cognitive dysfunction, which affect the quality of life and daily functioning of survivors of the infection[6].

Studies indicate that even after acute symptoms resolve, many patients continue to experience chronic symptoms, with some conditions persisting for months or even years after the initial infection[3]. These symptoms can affect different organic systems and vary in intensity, causing a significant impact on physical and mental health[6].

This study aims to evaluate respiratory muscle strength, lung function, and persistent symptoms of COVID-19 in hospitalized and non-hospitalized individuals one year after infection.

METHODS

The observational study, with a quantitative approach, has a cross-sectional design. The research covered two groups of participants: the first was composed of individuals who required hospitalization due to SARS-CoV-2 infection in the Semi-intensive Care Unit of a reference hospital for infectious diseases in Fortaleza, CE. The second group consisted of patients infected with SARS-CoV-2, who did not require hospitalization and were treated on an outpatient basis.

The study was approved by the Research Ethics Committees of the following locations: the São José Hospital for Infectious Diseases (HSJ), with opinion number 4,366,821, and the Federal University of Ceará (UFC), with opinion number 5,759,326. Both commissions followed the principles of Resolution 466/2012 of the National Health Council[7].

The recruitment of hospitalized participants occurred at the time of admission to the aforementioned hospital unit, with the collection of sociodemographic and clinical data directly from the medical records between February 2021 and March 2022, while non-hospitalized participants were recruited through the dissemination of the research on social media, the study being conducted during the years 2022, 2023, and 2024. Both groups were evaluated at the Cardiorespiratory Physiotherapy Laboratory at the UFC one year after infection.

According to the Ministry of Health[8], mild cases are characterized by patients who do not require supplemental oxygen, do not present significant changes in laboratory and radiographic examinations, and, therefore, could be monitored on an outpatient basis, without the need for hospitalization. Participants were recruited from individuals who volunteered for the study after the research was publicized on social media.

The sample was non-probabilistic for convenience.

The group of hospitalized patients included people ≥18 years old with COVID-19 confirmed by laboratory examination, excluding those transferred to other hospital units, with a previous neurological history, without discharge from the monitoring unit, or who died before or during the study. Participants who were impossible to contact or who voluntarily withdrew from the study were also excluded.

For mild cases of COVID-19, individuals ≥18 years old with a confirmed diagnosis one year ago were included, excluding those with cognitive or communication disorders, unable to perform respiratory tests, or who had reinfection during the data collection period.

At the initial time of collection, demographic and clinical variables, such as age, gender, BMI, comorbidities, and lifestyle habits, were obtained from the electronic medical records of hospitalized patients. One year after the illness, participants responded to a questionnaire to confirm and complement sociodemographic data, in addition to reporting COVID-19 symptoms, history of infection, and need for rehabilitation.

Maximum inspiratory (MIP) and expiratory (MEP) pressures were measured with an analog manometer, considering the highest value among three measurements, as long as the variation between them was < 10%[9]. The predicted MIP and MEP values, expressed as a percentage of the predicted value, were calculated according to the recommendations of Neder (1999)10 adjusted for the Brazilian population[11].

Spirometry was performed without the use of a bronchodilator, using a Contec Sp80b Digital Portable Spirometer, with results interpreted based on the criteria of the Official Technical Statement of the American Thoracic Society and the European Society of Pulmonology[12] and reference values for the Brazilian population[13].

Data analysis

The data were tabulated and analyzed using a statistical program. Data relating to sample characterization were analyzed with descriptive statistics using means, standard deviation, frequencies, and percentages when most appropriate.

For comparison between groups, the independent T-test and the chi-square test were used. Regarding the individual analysis of each group in relation to possible predictors of the presence or absence of symptoms in the post-COVID-19 period, logistic regression was used. The independent variables for the two groups were selected from a previous study based on clinical importance, risk factors for post-COVID symptoms, or potential confounders for the mentioned outcomes. Values were considered statistically significant when $p<0.05$.

RESULTS

The study included 160 participants, with 80 individuals requiring hospitalization and 80 considered mild cases. Among

hospitalized patients, 52.5% were male. The mean age of the participants was 55.8 ± 15.87 years, and the mean body mass index (BMI) was 28.85 ± 4.85 kg/m². Among the participants, 37.5% had comorbidities, with cardiovascular diseases being the most prevalent, affecting 27.5%, followed by metabolic conditions, 15% (Table 1).

The average length of stay was 10 days ± 7.8. The majority of patients, 81.3%, did not require an Intensive Care Unit (ICU), while 18.7% needed this support, with an average length of stay in the ICU of 6.2 days ± 7.04.

Regarding oxygen support, of the total, 85% of patients received nasal support, 10% reservoir mask, and 5% high flow nasal cannula. Mechanical ventilation was necessary in 15 (18.7%), with an average of 13.25 ± 4.06 days. Tracheostomy was performed in 10 participants (12.5%). Additionally, 8 patients (10%) required neuromuscular blockade (NMB) for more than one day.

The patients' mean C-Reactive Protein (CRP) was 136.6 mg/L ± 100.86. Chest computed tomography (CT) revealed that 65 (81.3%) of the patients had lung involvement <50%.

In the acute phase, the most common symptoms were: dyspnea (91.2%), fever (90%), myalgia (81.2%), cough (68.7%), and sore throat (50%). Others, such as headache, diarrhea, anosmia, ageusia, and vomiting, were reported less frequently (Table 1).

Table 1. Demographic, anthropometric, and clinical characteristics of participants who required hospitalization due to COVID-19 (n=80).

Variables	Average/n	Standard deviation / %
Age (years)	55,80	15,87
BMI (kg/m2)	28,85	4,85
Gender		
Feminine	38	47,5
Masculine	42	52,5
Presence of comorbidity		
Yes	30	37,5
No	50	62,5
Type of comorbidity		
Cardiovascular	22	27,5
Metabolic	12	15,0
Respiratory	04	5,0
Infectious	02	2,5
Neurological	01	1,25
Alcoholic		
Yes	33	41,2
No	47	58,8
Smoker		
Yes	05	6,25
No	75	93,7
Hospitalization period		
Days of Hospitalization	10	7,8
Required ICU		
Yes	15	18,7
No	65	81,3
Days of ICU stay	6,20	7,04
O2 support		
Nasal Catheter	68	85
Reservoir Mask	08	10
High flow therapy (HFT)	04	5
Required Mechanical Ventilation		
Yes	15	18,7
No	65	81,3
Mechanical Ventilation Days Required tracheostomy	13,25	4,06
Yes	10	12,5
No	70	87,5
Use of BNM for more than one day	08	10,0
CRP (mg/L)	136,6	100,86
Change in CT		
Less than 50%	65	81,3
Greater than or equal to 50%	15	18,7
Symptoms in the acute phase of the disease		
Dyspnea	73	91,2
Fever	72	90,0
Cough	55	68,7
Myalgia	65	81,2
Headache	25	31,2
Diarrhea	18	22,5
Anosmia	20	25,0
Ageusia	10	12,5
Sore throat	40	50,0
Vomiting	06	7,5

Legend: BMI: Body mass index; ICU: Intensive care unit; O2: Oxygen; BNM Support: Neuromuscular blocker; CRP: C-reactive protein; CT: Computed tomography.

Table 2 presents the characterization of the 80 study participants who did not require hospitalization. The average age of these participants was 53.2 years ± 13.54, with an average BMI of 27.86 kg/m2 ± 6.05, 53.7% were female.

Among the participants, 45% stated they had no comorbidities, while 35% mentioned pre-existing conditions. The most prevalent were cardiovascular diseases (23.7%, followed by metabolic conditions (13.7%).

As for alcoholism, 43.7% of participants reported alcohol consumption. Regarding smoking, 8.7% of participants were smokers.

In the acute phase of COVID-19, the most reported symptoms were: 87.5% fever, 78.7% myalgia, and 65% cough. Followed by less reported symptoms such as sore throat, dyspnea, anosmia, headache, diarrhea, ageusia, and vomiting.

Table 2. Characterization of study participants who did not require hospitalization (n=80).

Variables	Average / n	Standard deviation / %
Age (years)	53,20	13,54
BMI (kg/m2)	27,86	6,05
Gender		
Feminine	43	53,7
Masculine	37	46,3
Presence of comorbidity		
Yes	28	35,0
No	42	45,0
Type of comorbidity		
Cardiovascular	19	23,7
Metabolic	11	13,7
Respiratory	03	3,75
Infectious	03	3,75
Neurological	03	3,75
Alcoholic		
Yes	35	43,7
No	45	56,3
Smoker		
Yes	07	8,7
No	73	91,3
Symptoms in the acute phase of the disease		
Dyspnea	20	25,0
Fever	70	87,5
Cough	52	65,0
Myalgia	63	78,7
Headache	20	25,0
Diarrhea	15	18,7
Anosmia	17	21,2
Ageusia	08	10,0
Sore throat	37	46,2
Vomiting	04	5,0

Legend: BMI: Body mass index.

No significant differences were observed between the hospitalized and non-hospitalized groups in the variables age (p=0.512), BMI (p=0.873), and presence of comorbidities (cardiovascular p=0.534, metabolic p=0.515, respiratory p=0.501, infectious p= 0.492, neurological p=0.458). Regarding gender, the percentage of women was 47.5% of those hospitalized and 53.7% of those not hospitalized, with no significant difference (p=0.281).

A significant difference was observed in the occurrence of dyspnea during the acute phase, present in 91.2% of those hospitalized and 25% of those not hospitalized ($p < 0.001$), revealing greater respiratory severity in the hospitalized group. Other symptoms, such as fever (p=0.542), cough (p=0.517), myalgia (p=0.442), headache (p=0.381), diarrhea (p=0.403), ageusia (p=0.425), pain in throat (p=0.538), and vomiting (p=0.439), did not show significant differences.

A higher proportion of hospitalized patients (33.7%) required help with activities of daily living compared to non-hospitalized patients (26.2%), although without a significant difference (p=0.213). Adherence to rehabilitation was statistically significant: 47.5% of those hospitalized underwent rehabilitation after the illness, compared to 2.5% of those not hospitalized (p=0.023) (Table 3).

Table 3. Comparison of COVID-19 clinical data, self-reported need for help, and rehabilitation after cure between hospitalized and non-hospitalized individuals.

Variables	P Participants (n=80) Hospitalized n/%	P Participants (n=80) Non- Hospitalized n/%	P valor
Age (years)-mean/SD	55,80±15,87	53,20±13,54	0,512
BMI (kg/m2)-mean/SD	28,85±4,85	27,86±6,05	0,873
Feminine	38 (47,5)	43 (53,7)	0,281
Type of comorbidity			
Cardiovascular	22 (27,5)	19 (23,7)	0,534
Metabolic	12 (15,0)	11 (13,7)	0,515
Respiratory	04 (5,0)	03 (3,75)	0,501
Infecciosa	02 (2,5)	03 (3,75)	0,492
Infectious	01 (1,25)	03 (3,75)	0,458
Symptoms in the acute phase of the disease			
Dyspnea	73 (91,2)	20 (25,0)	<.001*
Fever	72 (90,0)	70 (87,5)	0,542
Cough	55 (68,7)	52 (65,0)	0,517
Myalgia	65 (81,2)	63 (78,7)	0,442
Headache	25 (31,2)	20 (25,0)	0,381
Diarrhea	18 (22,5)	15 (18,7)	0,403
Anosmia	15 (25,0)	40 (50,0)	0,041*
Ageusia	08 (10,0)	10 (12,5)	0,425
Sore throat	37 (46,2)	40 (50,0)	0,538
Vomiting	06 (7,5)	04 (5,0)	0,439
Rehabilitation after infection	38 (47,5)	02 (2,5)	0,023*
Needed help with ADLs	27 (33,7)	21 (26,2)	0,213

Legend: SD: Standard deviation; BMI: Body mass index; ADLs: Activities of Daily Living *p < 0.05.

Table 4 compares persistent symptoms between hospitalized and non-hospitalized patients one year after COVID-19. At least one persistent symptom was reported by 42.5% of those hospitalized and 45% of those not hospitalized, with no significant difference (p=0.716). However, fatigue was more prevalent in those not hospitalized (42.5%) than in those hospitalized (16.2%), with a significant difference (p=0.032).

Other persistent symptoms included fatigue on exertion (17.5% hospitalized vs. 21.2% not hospitalized), palpitations (2.5% vs. 3.7%), and osteomyoarticular pain (11.2% vs. 8.7%), with p=0.613; p=0.521; p=0.412, respectively. Gastrointestinal changes were reported by 7.5% of those hospitalized and 5% of those not hospitalized (p=0.424), while anosmia and ageusia prevailed similarly between the groups.

Memory loss was reported by 41.2% of those hospitalized and 38.7% of those not hospitalized (p=0.813), while hair loss occurred in 7.5% and 5% respectively (p=0.436).

Table 4. Persistent symptoms, respiratory muscle strength, and lung function one year after COVID-19 infection among hospitalized and non-hospitalized individuals.

Variables	Participants (n=80) Hospitalized n/%_	Participants (n=80) Non Hospitalized n/%	P value
Persistent symptoms			
Minimum 1 persistent symptom	34 (42,5)	36 (45,0)	0,716
Fatigue	13 (16,2)	34 (42,5)	0,032*
Fatigue from exertion	14 (17,5)	17 (21,2)	0,613
Palpitation	02 (2,5)	03 (3,7)	0,521
Headache	30 (37,5)	28 (35,0)	0,733
Osteomioarticular pain	09 (11,2)	07 (8,7)	0,412
Sore throat	10 (12,5)	08 (10,0)	0,569
Gastrointestinal changes	06 (7,5)	04 (5,0)	0,424
Anosmia	09 (11,2)	07 (8,7)	0,458
Ageusia	04 (5,0)	06 (7,5)	0,581
Memory loss	33 (41,2)	31 (38,7)	0,813
Hair loss	06 (7,5)	04 (5,0)	0,436
Respiratory muscle strength			
MIP (cmH2O)			**0,421**
Value obtained	100,20±32,11	97,27±34,85	
% of forecast	94,54±33,45	91,66±35,84	
MEP (cmH2O)			0,518
Value obtained	95,13±22,43	93,19±24,56	
% of forecast	75,12±23,11	73,03±29,12	
Lung function			0,021*
CFV (L)			
Value obtained	2,80±1,00	3,53±1,00	
% of forecast	60,01±11,14	89,02±10,94	
FEV1 (L)			0,323
Value obtained	3,05±1,52	2,76±1,05	
% of forecast	82,17±16,47	83,39±18,11	
PFE (L)			0,614
Value obtained	4,85±3,00	5,00±2,28	
% of forecast	80±24,02	82,00±22,90	

Legend: *p <0.05; SD: Standard deviation; MIP: Maximum Inspiratory Pressure; MEP: Maximum Expiratory Pressure; CFV: Forced Vital Capacity; FEV1: Forced Exhaled Volume in the first second; PFE: Peak Expiratory Flow.

Regarding respiratory muscle strength, maximum inspiratory pressure (MIP) and maximum expiratory pressure (MEP) did not show statistically significant differences between the groups. The percentage of predicted MIP value for hospitalized and non-hospitalized patients was (94.54±33.45% vs. 91.66±35.84%; p=0.421), and the percentage predicted for MEP was also similar (75.12±23.1% vs. 73.03±29.12%; p = 0.518).

In relation to lung function, forced vital capacity (FVC) showed a significant difference between the groups (p=0.021), with hospitalized versus non-hospitalized patients presenting a percentage of predicted (60.01±11.14% vs. 89.02±10.94%).

The forced expiratory volume in the first second (FEV1) and peak expiratory flow (PEF) did not show significant differences between the groups, with the predicted percentage of hospitalized versus non-hospitalized patients being (82.17±16.47% vs. 83 .39±18.11%; p=0.323). While for PEF it was (80±24.02% vs 82±22.90%; p= 0.614 (table 4).

Table 5 shows BMI (OR 1.07; 95% CI 1.02–1.15; p = 0.001) and number of comorbidities (OR 2.08; 95% CI 0.52–2.24; p = 0.040) as significant predictor variables for persistent symptoms in individuals hospitalized for COVID-19.

Although other variables such as age (p=0.054) and days of hospitalization (p=0.067) showed a tendency towards association, they did not reach statistical significance. CRP and pulmonary involvement ≥ 50% identified on CT did not demonstrate a significant association with persistent symptoms. Dispositions of the number of comorbidities (OR 2.00; 95% CI 1.08–5.56; p = 0.020) and the number of symptoms in the acute phase (OR 4.05; 95% CI 1.30–10.54 ; p = 0.014) were identified as significant predictor variables for persistent symptoms in non-hospitalized individuals (Table 5).

Regarding BMI and age, neither was indicated as a predictor of persistent symptoms one year after infection in non-hospitalized individuals (OR of 1.02; 95% CI: 1.99–2.34, p=0.074; OR of 0.96 (95% CI; 1.25–1.85; p = 0.061, respectively).

Table 5. Predictive Variables of Persistent Symptoms One Year After COVID-19 Infection in Hospitalized and Non-Hospitalized Individuals in the Acute Phase.

Variables	OR	Confidence interval 95%		p
		Lower limit	Upper limit	
Hospitalized				
Age	0,97	1,09	1,21	0,054
Days of hospitalization	1,07	0,99	1,16	0,067
BMI	1,07	1,02	1,15	0,001*
CRP	0,99	0,99	1,00	0,795
Number of comorbidities	2,08	0,52	2,24	0,040*
CT ≥ 50%	1,05	2,03	60,21	0,230
Not Hospitalized				
Age	0,96	1,25	1,85	0,061
BMI	1,02	1,99	2,34	0,074
Number of comorbidities	2,00	1,08	5,56	0,020*
Number of symptoms in the acute phase	4,05	1,30	10,54	0,014*

Legend: CI 95%: Confidence interval 95%; OR: Odds ratio; BMI: Body mass index; CRP: C-reactive protein; CT: Computed tomography.

DISCUSSION

After one year, both groups showed persistent symptoms, with no statistically significant difference, except for fatigue, which was more prevalent among participants with mild cases. Regarding lung function, those hospitalized exhibited greater impairment in FVC, suggesting a more restrictive pattern. As for predictive factors, BMI and the number of comorbidities were associated with a greater probability of prolonged symptoms in those hospitalized, while, among those not hospitalized, the number of symptoms in the acute phase and the number of comorbidities were predictors of a greater chance of symptoms. persistent after one year of infection.

The predominance of fatigue in mild cases, observed in our study, has also been reported in other studies[14,15]. Fernández-de-las-Peñas[15] pointed out that, after two years, fatigue was the symptom most frequently reported by hospitalized and non-hospitalized individuals, being more prevalent among those not hospitalized. This finding was also corroborated by a systematic review, which showed that, 90 days after the initial infection, fatigue was the most reported symptom among non-hospitalized individuals[3].

Crook et al. (2021)[16] suggest that chronic fatigue may be the result of failures in inflammatory responses, hypometabolism in the frontal lobe and cerebellum, psychological factors, or direct infection of skeletal muscle by SARS-CoV-2. Post-COVID-19 fatigue shares several features with myalgic encephalomyelitis/ chronic fatigue syndrome (ME/CFS).

In this context, it is important to highlight that, in our study, only two patients in the non-hospitalized group underwent rehabilitation. Considering that interventions, such as pulmonary rehabilitation, are widely recognized as playing a crucial role in recovering individuals' functionality, the absence of this practice can have long-term consequences.

A randomized clinical trial investigated the effects of moderate to high intensity aerobic and respiratory exercises on cardiorespiratory fitness and quality of life in post-COVID-19 patients. After five weeks of training, with three weekly sessions, participants showed significant improvements in cardiorespiratory fitness, dyspnea, and quality of life[17]. These results suggest that rehabilitation may be highly beneficial for post-COVID-19 recovery.

Furthermore, a narrative review of pulmonary rehabilitation programs for patients with long COVID emphasized that persistent symptoms, such as shortness of breath and fatigue, reduce functional capacity, as occurs in chronic respiratory diseases. An essential aspect of this treatment is the personalization of exercise programs, taking into account respiratory disorders, post-exertional malaise, and possible adverse reactions to physical activity[18]. Thus, the predominance of fatigue in mild cases may be associated with the neglect of these symptoms and their repercussions on daily life.

The results of this study revealed a significant difference in FVC between the groups analyzed. The predicted FVC percentage was significantly lower in hospitalized patients compared to non-hospitalized patients. Some studies indicate a tendency towards a restrictive physiology in patients hospitalized with moderate to severe COVID-19, highlighting characteristics of this condition through radiological changes on computed tomography and changes in pulmonary function testing, such as FVC and diffusion of carbon monoxide (DLCO)[19–22].

The justification for this change may lie in the effects of direct viral toxicity, which cause continuous damage to the respiratory system. In patients with COVID-19 and persistent dyspnea, an increase in the levels of inflammatory cytokines, such as IL-1β, IL-6, and IL-8, was observed, which may contribute to the development of pulmonary fibrosis[23–25].

Furthermore, changes in the airway immune microenvironment, characterized by an increase in the expression of proteins related to apoptosis and epithelial injury, were identified in patients with long COVID, indicating a possible role for prolonged activation of cytotoxic T cells in long-term lung injury[26]. These immunological processes are associated with systemic inflammation and negatively correlated with lung function, reinforcing the hypothesis that SARS-CoV-2-specific T cells play an essential role in chronic respiratory manifestations[27].

Another interesting aspect observed was that, among those not hospitalized, although they did not present changes in lung function, the perception of fatigue during exertion was reported by 21.2% of the participants, a higher percentage than that observed among those hospitalized (17.5%). Although there is no statistically significant difference, it is important to consider that changes in lung function are distinct from functionality, and both groups can develop disabilities that impact daily activities[28].

The analysis of predictors of post-COVID syndrome presents varied results between studies. Carvalho-Schneider et al.[29] identified hospitalization and the age group of 40-49 years as the main predictors, while factors such as comorbidities, gender, and initial symptoms were not significant. Goertz et al.[14], on the other hand, highlighted the number of initial symptoms as the main predictor of persistent symptoms, focusing on fatigue, which had a significant association with impaired physical activity.

In the present study, we observed that, among those hospitalized, the predictive factors were BMI and number of comorbidities, the latter being also reported as a predictor in another study[15]. On the other hand, Estiri et al.[30] identified some phenotypes among non-hospitalized patients with COVID-19, female gender, and the number of initial symptoms at hospital admission, but not the severity of COVID-19, as potential risk factors for long COVID. But these results are based on a follow-up period of less than six months after infection.

In our analysis, we identified the number of symptoms in the acute phase as a predictor of long COVID among those not hospitalized. Furthermore, the number of comorbidities also remained a predictor, as observed in the study by Fernández et al. (2022)[15]. These findings support the theory that a higher viral load in the acute phase of infection is associated with an exaggerated immune response, which in turn is associated with the development of long COVID[29].

Among the limitations of this study, the absence of the pulmonary diffusion test stands out, widely reported in the literature as one of the main tests to identify changes in lung function, often in combination with computed tomography. The cross-sectional design of the study represents another limitation, as it prevents the analysis of cause-and-effect relationships. Finally, the absence of a control group composed of uninfected individuals restricts the possibility of directly evaluating the association between SARS-CoV-2 infection and general and specific post-COVID-19 symptoms.

CONCLUSION

One year after infection, both groups continued to show symptoms of COVID-19, with fatigue being reported more significantly among those not hospitalized. In terms of lung function, those hospitalized demonstrated greater impairment in FVC, indicating a more restrictive pattern. With regard to predictive factors, BMI and the number of comorbidities were associated with a greater likelihood of prolonged symptoms among those hospitalized. On the other hand, among those not hospitalized, the main predictors of persistent symptoms after one year were the number of symptoms in the acute phase and the number of comorbidities.

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