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ORIGINAL RESEARCH

Physical capacity assessment in patients hospitalized with COVID-19 diagnose

Avaliação da capacidade física em pacientes hospitalizados com diagnóstico de COVID-19

Evaluación de la capacidad física en pacientes hospitalizados por Covid-19

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ABSTRACT | SARS-CoV-2 infection can cause severe acute respiratory syndrome (SARS), leading to hypoxemia. Physical capacity assessment can be performed before hospital discharge using submaximal exercise testing. This study sought to assess physical capacity and exercise tolerance with the six-minute step test (6MST) in hospitalized COVID-19 patients who required oxygen (O_2) support during hospitalization. A prospective, interventional study was conducted with patients aged from 18 to 90 years who required oxygen therapy during hospitalization. Assessment was performed using Perme Score, followed by the 6MST tests, assessing the peripheral oxygen saturation (SpO_2), heart rate (HR), blood pressure (BP), and subjective exertion perception by Borg Scale, before and immediately after the 6MST. A total of 31 patients, with a mean age of 51.9 years, were evaluated. Nasal cannula (NC) was the most used device (64.5% of patients). Regarding HR, BP, and Borg Scale, their mean value increased after 6MST. SpO_2 showed a lower mean value after 6MST. Out of the 86.9% of patients who completed the test, 48.3% completed it with interruptions, and 12.9% had to suspend it. The 6MST was able to assess physical capacity and exercise tolerance, proving to be an effective tool for evaluating COVID-19 patients.

Keywords | Exercise Test; Severe Acute Respiratory Syndrome; Oxygen Inhalation Therapy; COVID-19; SARS Virus.

RESUMO | A infecção por SARS-CoV-2 pode ocasionar a síndrome respiratória aguda grave (SRAG), levando a hipoxemia. A avaliação da capacidade física pode ser realizada anteriormente à alta hospitalar, através de testes de exercícios submáximos. O objetivo deste estudo foi avaliar a capacidade física e a tolerância ao exercício físico por meio do teste de degrau de seis minutos (TD6) em pacientes hospitalizados com diagnóstico de COVID-19 que fizeram uso de suporte de oxigênio (O_2) durante a internação. Trata-se de um estudo prospectivo e intervencionista, incluindo pacientes com idade entre 18 e 90 anos, que necessitaram de oxigenoterapia durante a hospitalização. Foi realizada avaliação através do Perme escore, seguida do TD6, com análise da saturação periférica de oxigênio (SpO_2), frequência cardíaca (FC), pressão arterial (PA) e percepção subjetiva do esforço através da escala de Borg, antes e imediatamente após o TD6. Foram avaliados 31 pacientes, com idade média de 51,9 anos. O dispositivo de O_2 mais utilizado foi o cateter nasal (CN), em 64,5% dos pacientes. Em relação à FC, PA e escala de Borg, pudemos observar um aumento no valor médio dessas variáveis após o TD6. A SpO_2 teve uma média menor quando comparada à avaliação inicial do TD6. O teste foi finalizado por 86,9% dos pacientes, sendo que, destes, 48,3% finalizaram com interrupções; 12,9% dos participantes suspenderam o teste. O TD6 foi

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capaz de avaliar a capacidade física e a tolerância ao exercício, tornando-se uma ferramenta eficaz para avaliação do paciente com COVID-19.
Descritores | Teste de Esforço; Síndrome Respiratória Aguda Grave; Oxigenoterapia; COVID-19; Vírus da SARS.

RESUMEN | La infección por SARS-CoV-2 puede provocar el síndrome respiratorio agudo severo (SRAS), resultando en hipoxemia. La evaluación de la capacidad física se puede realizar antes del alta hospitalaria mediante pruebas de ejercicio submáximas. El objetivo de este estudio fue evaluar la capacidad física y la tolerancia al ejercicio a través del test de escalón de seis minutos (TE6) en pacientes hospitalizados por Covid-19 que utilizaron soporte de oxígeno (O2) durante la hospitalización. Se trata de un estudio prospectivo e intervencionista, en el que se incluyeron a pacientes con edades entre los 18 y los 90 años, que necesitaron la oxigenoterapia durante su hospitalización. La evaluación se realizó mediante el puntaje de Perme, seguido del TE6, con análisis de saturación de oxígeno periférico (SpO2), frecuencia cardíaca (FC), presión arterial (PA) y esfuerzo percibido mediante la escala de Borg, antes e inmediatamente después del TE6. Se evaluaron a 31 pacientes, con una edad media de 51,9 años. El dispositivo de O2 más utilizado fue el catéter nasal (CN) por el 64,5% de los pacientes. Con relación a la FC, PA y la escala de Borg, se observa un aumento en el valor medio de estas variables después del TE6. La SpO_2 tuvo una media más baja en comparación con la evaluación inicial del TE6. El 86,9% de los pacientes completaron el test, de los cuales el 48,3% terminó con interrupciones; y el 12,9% lo suspendió. El TE6 pudo evaluar la capacidad física y la tolerancia al ejercicio, lo que resulta ser una herramienta eficaz para evaluar a los pacientes con Covid-19.
Palabras clave | Prueba de Esfuerzo; Síndrome Respiratorio Agudo Grave; Terapia por Inhalación de Oxígeno; Covid-19; Virus del SRAS.

INTRODUCTION

In January 2020, a new coronavirus (SARS-CoV-2) was identified in Wuhan, China, and was officially associated as the cause of an outbreak of viral pneumonia, called COVID-19. Coronavirus infection causes a respiratory condition known as severe acute respiratory syndrome (SARS)[1]. In Brazil, from 2020 to February 2022, more than 28 million cases of COVID-19 were confirmed. In 2022, 75,494 hospitalizations and 20,525 deaths from SARS were recorded and confirmed as SARS-CoV-2[2].

The SARS caused by COVID-19 is mainly characterized by severe hypoxemia[3]. As clinical signs of this pathology, patients present flu-like symptoms combined with dyspnea or tachypnea, with a respiratory rate (RR) of ≥30 incursions per minute, and/or hypoxemia verified by peripheral oxygen saturation (SpO_2) <92% in room air[4]. Some individuals may present "silent" hypoxemia due to an unbalanced nervous system, affecting breath control[5].

Hypoxia is one of the main causes of multiple organ failure and death in patients with COVID-19, making oxygen therapy an important treatment[6]. Non-invasive ventilation (NIV) has become a treatment option for when the criteria for orotracheal intubation (OTI) has not yet been met, potentially avoiding OTI[7].

Obese individuals require a longer period to achieve oxygen (O_2) weaning, when compared to non-obese individuals, due to worsening of the pulmonary condition with lower partial pressure of O_2 in the arterial blood (PaO_2) and SpO_2 on admission, requiring higher O_2 flows and a longer period of hospitalization[8].

Physical capacity is a significant factor of evaluation in healthy individuals and patients with chronic lung disease, and it can generally be analyzed by submaximal exercise tests, which assess exercise tolerance and are more representative of daily physical activities[9]. The 6-minute step test (6MST) has been used since the 1920s to assess physical capacity in patients with pulmonary diseases due to its low cost and its feasibility in small spaces[10].

Our study aims to evaluate, with the 6MST, the physical capacity and tolerance to physical exercise of hospitalized patients diagnosed with COVID-19 who required O_2 support during hospitalization.

METHODOLOGY

Study specifications

This is a prospective and interventional study, conducted at the Hospital de Clínicas (HC) of the

University of Campinas (Unicamp). All participants signed an informed consent form. Data collection was performed via the AGHUse system, and medical records and in-person data collection were performed in the adult care unit (ACU), from May to October 2021.

Inclusion criteria

Hospitalized individuals, regardless of gender, diagnosed with COVID-19 (obtained by polymerase chain reaction test [RT-PCR] positive for SARS-CoV-2) who required O_2 support during hospitalization, with a minimum score of 29 points on the Perme score, and aged from 18 to 90 years were selected for the study.

Exclusion criteria

The exclusion criteria were as follows: patients who required invasive mechanical ventilation (IMV) during hospitalization; patients diagnosed with pulmonary thromboembolism (PTE); patients who had unstable angina; previous pneumopathy; patients who presented fracture of the lower limbs; balance deficit; acute myocardial infarction (AMI); patients that could not understand the team commands; and patients presenting SpO_2<92% on the day of the test.

Evaluation

An evaluation was performed 24 hours after the total withdrawal of the O_2 support, in which the Perme score functionality scale was applied.

Application of the 6-minute step test

The individuals were subjected to the 6MST, conducted on a step with 20cm height, anti-slip rubber floor, and without hand support. Participants were instructed to go up and down the platform as fast as possible for six minutes, alternating the lower limbs. During the test, they were encouraged by voice commands, such as "you are doing great, keep it up[10]." The 6MST was applied by two evaluators, one to command the test and the other to verify the steps count.

Items evaluated during the 6-minute step test

Blood pressure (BP), heart rate (HR), SpO_2, and Borg scale were analyzed during rest and immediately after the 6MST. SpO_2 and HR were measured using a G-Tech portable oximeter, Model Oled Graph, and BP was measured using the manual sphygmomanometer; mean blood pressure (MBP) was calculated using the following equation: [SBP+(2×DBP)÷3] (SBP – systolic blood pressure; and DBP – diastolic blood pressure).

Criteria for interrupting of the 6-minute step test

Patients who presented the following criteria had their 6MST test interrupted: desaturation (SpO_2<85%); HR greater than the submaximal, determined by the equation: [submaximal HR (bpm)=(220–Age)×0.85] for men and [submaximal HR (bpm)=(210–Age)×0.85] for women; angina; malaise; dizziness; or at the patient's request to interrupt the test. When interruption was necessary, the individuals waited in sitting position until the HR decreased 10bpm of the submaximal and SpO_2 presented a value ≥88%, when it was possible to return to the test[10]. Suspension of the 6MST occurred in patients who did not reach the necessary parameters within six minutes and, therefore, did not complete the test.

Statistical analysis

Statistical analyses were performed using the BioStat 7.3 program. the Kolmogorov-Smirnov test was used to verify the distribution of normality of the data. The quantitative data were presented in as mean and standard deviation (SD), and the qualitative data were presented as absolute number and percentage. To compare the hemodynamic variables, the qualitative variables, and the quantitative data between the groups, the t-test, chi square test, and the analysis of variance (ANOVA) test were used, respectively. Also, $p<0.05$ was adopted as significance level.

Flowchart

Figure 1 shows the flowchart of the study's methodology.

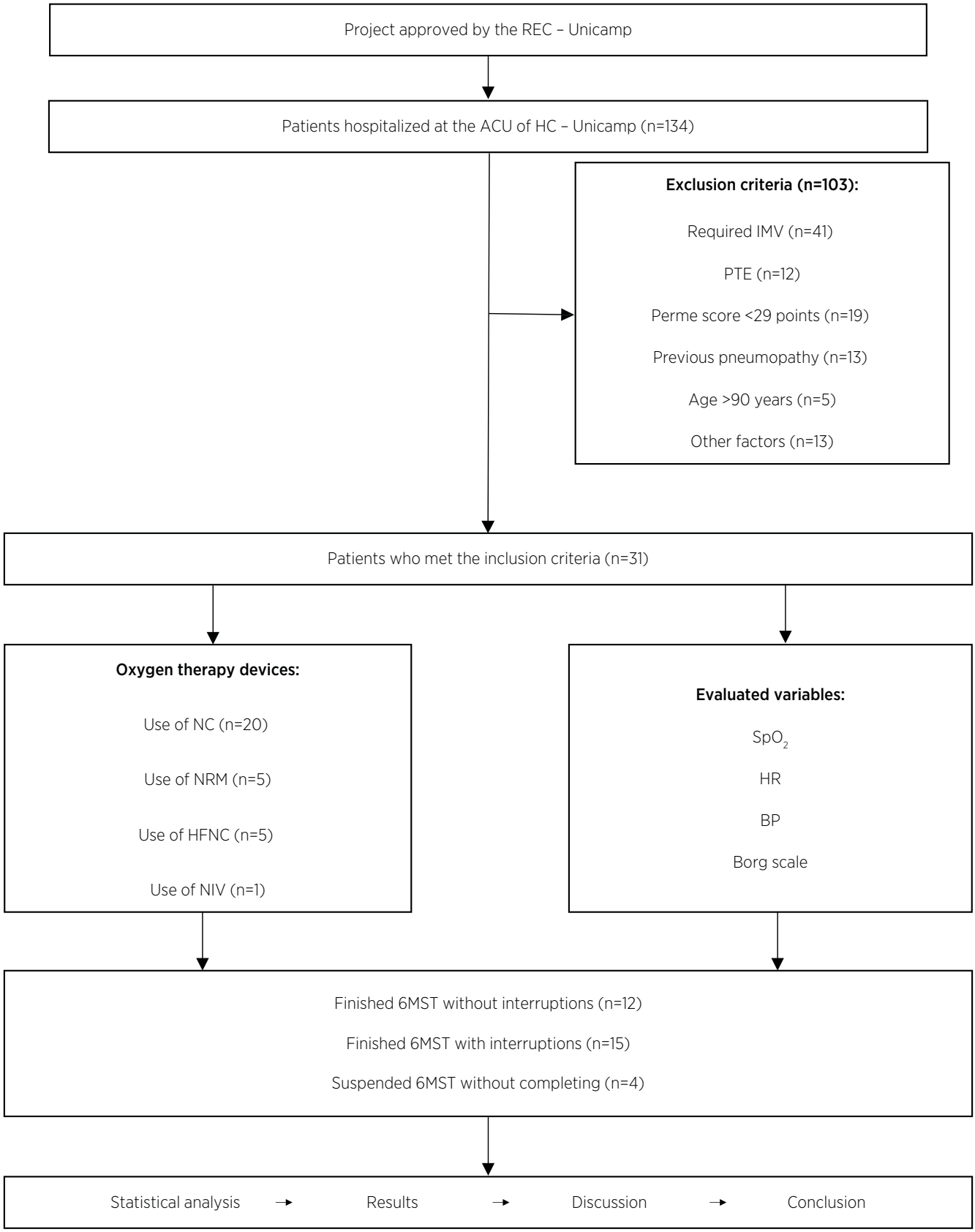

Figure 1. Study flowchart

REC: Research Ethics Committee; ACU: adult care unit; n: number of subjects; IMV: invasive mechanical ventilation; PTE: pulmonary thromboembolism; NC: O_2 nasal cannula; NRM: non-rebreather mask with O_2 reservoir; HFNC: high-flow nasal cannula; NIV: noninvasive ventilation; SpO_2: peripheral oxygen saturation; HR: heart rate; BP: blood pressure; 6MST: 6-minute step test.

RESULTS

A total of 134 patients were selected, of which 103 were excluded: 41 required OTI; 19 had Perme score of <29 points; 12 were diagnosed with PTE; 13 had previous pneumopathy; five were aged >90 years; and 13 patients were excluded due to other factors, such as inability to understand commands, AMI during hospitalization, and SpO_2<92%.

The sample consisted of 31 individuals. Table 1 describes participant's characteristics, with 18 (58%) men and 13 (42%) women. When comparing age, weight, height, and body mass index (BMI), women had a higher mean in relation to age, 52.3±9.35 years, and mean BMI of 32.7±3.88kg/m^2.

Table 1. Demographic characteristics of participants

	Men (n=18)	Women (n=13)	All participants (n=31)
Age (years)	51.6±14.3	52.3±9.35	51.9±2.2
Weight (kg)	92.6±21.6	82.1±12.4	88.2±18.8
Height (m)	1.75±0.08	1.58±0.08	1.67±0.11
BMI (kg/m^2)	29.9±4.76	32.7±3.88	31.1±0.8

Data presented in mean and standard deviation (SD); n: number of subjects; BMI: body mass index.

Our sample presented the following comorbidities: 13 patients (41.9%) with arterial hypertension (SAH); 9 (29%) with diabetes mellitus (DM); 18 (58%) with obesity; 2 (6.4%) with asthma; 1 (3.2%) with arrhythmia; dyslipidemia in 2 patients (6.4%); hypothyroidism in 3 (9.6%); chagas disease in 1 (3.2%); previous stroke in 1 (3.2%); and only 1 (3.2%) had no comorbidities. The D-dimer values of admission had a mean of 778.2±179.1µd/mL. The active prone position was performed by 23 (74.1%) participants, and the mean length of hospital stay was 7.1±0.4 days. We identified that 17 (54.8%) participants had not yet received any dose of the vaccine against COVID-19, 8 (25.8%) received the first dose, and 6 (19.3%) completed the two doses of the immunization schedule.

Regarding oxygen therapy devices used by the participants, 20 (64.5%) used an O_2 nasal cannula (NC), 5 (16.1%) used a non-rebreather mask with O_2 reservoir (NRM), 5 (16.1%) required a high-flow nasal cannula (HFNC), and 1 (3.2%) used NIV.

Table 2 shows the signs and symptoms evaluated at rest and immediately after the sixth minute of the 6MST. MBP (p=0.02), HR (p<0.01), and Borg scale (p<0.01) showed significant increases after the test. We observed a non-significant drop in SpO_2 (p=0.009) in the sixth minute.

Table 2. Comparative analysis of the evaluated signs and symptoms

Evaluated signs	Resting	On 6'	p-value
MBP	98.0±12.1	106.9±18.0	0.02*
HR	87.5±15.4	124.9±12.9	<0.01*
SpO_2	93.9±1.4	91.9±3.8	0.009
Borg scale	0.6±1.0	5±2.3	<0.01*

Data presented in mean and standard deviation (SD). 6': sixth minute; *p-value: significance ≤0.05; MBP: mean blood pressure; HR: heart rate; SpO_2: peripheral oxygen saturation.

The test was completed by 27 (87%) participants, of which 12 (38.7%) finished without interruptions and 15 (48.3%) required some interruption, mainly due to HR above the submaximal. The 4 (12.9%) who did not finish the test and required suspension, presented a SpO_2<85% (Table 3). Out of these, two used NC, one NRM, and one NIV.

Table 3. Characteristics observed in the 6-minute step test

Item evaluated during 6MST	n=31 (%)
Finished without interruptions	12 (38.7%)
Finished with interruptions	15 (48.3%)
SpO_2<85%	2 (13.3%)
HR>submaximal	8 (53.3%)
Fatigue complaint	5 (33.3%)
Suspension of 6MST due to SpO_2<85%	4 (12.9%)

6MST: six-minute step test; n: number of participants; HR: heart rate; SpO_2: peripheral oxygen saturation.

The participants climbed an average of 77.6±4.8 steps and, according to data from Table 4, there was a significant value (p=0.0005) to the number of steps. We observed that the patients who completed the 6MST without interruptions presented lower D-dimer values when compared with the participants who needed to interrupt the test. The mean D-dimer value was 1,023.5±1,334µd/mL. The mean BMI was higher in participants who interrupted the test, with 32.6±8.3kg/m^2. The prone position was performed by 13 (86.6%) participants who interrupted the 6MST, 3 (75%) who required suspension, and 7 (58.3%) who performed the pronation and finished without interruptions.

Table 4. Determining factors for completion of the 6-minute step test

	Suspended (n=4)	Finished with interruptions (n=15)	Finished without interruptions (n=12)	p-value
Age	51.5±18.2	52.5±13.8	51.3±8.8	0.96
Men	3 (75%)	9 (60%)	6 (50%)	0.84
Steps	37.7±7.8	76.4±23.3	92.3±20.7	0.0005*
D-dimer	366.4±468.4	1,023.5±1334.8	608.8±459.6	0.39

(continues)

Table 4. Continuation

	Suspended (n=4)	Finished with interruptions (n=15)	Finished without interruptions (n=12)	p-value
Length of hospital stay	7.7±2.7	7.4±3.0	6.5±2.2	0.66
BMI	32.6±8.3	30.2±4.5	31.6±3.1	0.60
Prone	3 (75%)	13 (86.6%)	7 (58.3%)	0.06

Data presented in mean and standard deviation (SD); n: number of participants; *p-value: significance ≤0.05; BMI: body mass index.

DISCUSSION

Hu et al.[11] describe that the mean age of individuals affected by SARS-CoV-2 infection was around 50 years, similar to the data found in our study; however, all age groups of the population seem to be susceptible to infection. Generally, men with comorbidities are more likely to develop severe respiratory diseases that require hospitalization. In this study, we observed that 58% of the participants were men and 42% were women.

In our study, only one patient did not present any comorbidity. A study by Barek, Aziz, and Islam[12] demonstrated that patients with at least one comorbidity are more susceptible to SARS-CoV-2 infection. Among the comorbidities observed, obesity (BMI=31.32±4.54kg/m^2) was prevalent. Participants who needed to suspend the 6MST presented a higher mean BMI (32.6±8.3kg/m^2) compared to the patients who finished the test. Simonnet et al.[13] showed that patients admitted to intensive care due to SARS-CoV-2 had a higher rate of obesity and that the severity of the disease increased with the BMI.

Fuglebjerg et al.[14] evaluated hypoxia and dyspnea with the 6-minute walk test (6MWT) in patients diagnosed with COVID-19 before hospital discharge. They observed that 50% of the patients had to interrupt the 6MWT due to SpO_2<90%, and there was a slight increase in dyspnea, measured by the Borg scale. In our study, six patients had to interrupt or suspend the 6MST due to a decrease in SpO_2<85%, with a significant increase in the Borg scale, confirming that stress tests are valuable tools for evaluating exercise-induced hypoxia in these patients.

In our study, participants who finished the 6MST without interruption climbed an average of 92.3 steps, and those who suspended or required interruption climbed, on average, 37.7 and 76.4, respectively. The participants performed the 6MST on a 20cm-high step and climbed an average of 77.6 steps, which demonstrates a lower performance when compared to the study by Oliveira et al.[15], performed with healthy individuals with the same type of step, climbed an average of 173.8 steps.

Rostami and Mansouritorghabeh[16] reported that patients in the early stages of COVID-19 infection had an increase in D-dimer concentrations, with a guarded prognosis. There is a high incidence of thrombolytic events, and it is believed that respiratory deterioration is associated with thrombosis[16]. Participants who completed the 6MST without interruptions obtained lower D-dimer values at admission, with a mean of 608µd/mL, whereas those who needed to interrupt the 6MST presented a mean of 1023.5µd/mL, while also demonstrating a lower tolerance to the stress test, since these patients showed greater severity of the disease.

In this study, 23 participants performed the spontaneous prone position during hospitalization, and, according to the hospital protocol, patients were instructed to maintain at least two sessions a day, each lasting two hours[17]. Out of these participants, six presented a decrease in SpO_2 during 6MST, and four had to suspend the test. Solverson, Weatherald, and Parhar[18] reviewed non-intubated patients and defined as severe hypoxemia the use of O_2≥5L/min flow to maintain a SpO_2≥90%. These patients were positioned in prone position for at least once during hospitalization, improving oxygenation and respiratory rate; however, part of the sample still required OTI[18]. Considering these results, patients who performed the prone position showed a more severe respiratory condition, and therefore, worst results in the 6MST.

CONCLUSION

The 6MST proved to be a useful and applicable tool to evaluate physical capacity and tolerance to exercise in patients hospitalized with COVID-19, using the studied variables. Considering that all patients will continue with their daily activities after hospital discharge and there is still a need for rehabilitation in an outpatient setting, the 6MST becomes an important evaluation data for post-COVID-19 rehabilitation. Notably, the 6MST is a stress test of easy application and low cost, easily performed in small spaces. We emphasize that other studies must contribute to the data found by us.

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