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Original research

Association of physical activity levels and the prevalence of COVID-19-associated hospitalization

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ABSTRACT

Objectives: We compared physical activity levels before the outbreak and quarantine measures with COVID-19-associated hospitalization prevalence in surviving patients infected with SARS-CoV-2. Additionally, we investigated the association of physical activity levels with symptoms of the disease, length of hospital stay, and mechanical ventilation.
Design: Observational, cross-sectional.
Methods: Between June 2020 and August 2020, we invited Brazilian survivors and fully recovered patients infected with SARS-CoV-2 to respond to an online questionnaire. We shared the electronic link to the questionnaire on the internet. We collected data about clinical outcomes (symptoms, medications, hospitalization, and length of hospital stay) and cofactors, such as age, sex, ethnicity, preexisting diseases, socioeconomic and educational, and physical activity levels using the International Physical Activity Questionnaire (IPAQ short version).
Results: Out of 938 patients, 91 (9.7%) were hospitalized due to COVID-19. In a univariate analysis, sex, age, and BMI were all associated with hospitalizations due to COVID-19. Men had a higher prevalence of hospitalization (66.6%, $p = 0.013$). Patients older than 65 years, obese, and with preexisting disease had a higher prevalence of COVID-19-related hospitalizations. In a multivariate regression model, performance of at least 150 min/wk (moderate) and/or 75 min/wk (vigorous) physical activity was associated with a lower prevalence of hospitalizations after adjustment for age, sex, BMI, and preexisting diseases (PR = 0.657; $p = 0.046$).
Conclusions: Sufficient physical activity levels were associated with a lower prevalence of COVID-19-related hospitalizations. Performing at least 150 min a week of moderate-intensity, or 75 min a week of vigorous-intensity physical activity was associated with 34.3% reduction in prevalence.

Practical implications

- COVID-19-associated hospitalization is an alarming issue with a higher cumulative rate in people aged 65 years and older.
- The World Health Organization recommends for adults at least 150 min/wk (moderate) and/or 75 min/wk (vigorous) physical activity
- In the new coronavirus pandemic being physically active is an adjuvant factor of protection against COVID-19-related hospitalizations.
- Our findings reinforce the hypothesis that in the new coronavirus pandemic being physically active might be an adjuvant factor of protection against COVID-19-related hospitalizations.

1. Introduction

The new severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is responsible for COVID-19 disease, initially discovered in the city of Wuhan, China, in late December 2019.[1] In March 2020, the World Health Organization (WHO) declared SARS-CoV-2 to be a

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worldwide pandemic. The virus quickly spread to several continents, and strongly impacting Brazil. This pandemic claimed numerous victims with millions of confirmed cases worldwide and thousands of deaths. In Brazil alone, until April 2021, >14 million cases have been confirmed leading to over 378,000 deaths, and these numbers are increasing dramatically. The main symptoms of the disease are fever, cough, shortness of breath, anosmia, and fatigue. COVID-19-associated hospitalization is an alarming issue with a higher cumulative rate in people aged 65 years and older[2] and with high public health care costs.

Because it is a new virus with such lethality, WHO and the governments of each country have adopted isolation and physical distancing as a preventive measure to contain the spread of the virus. Additionally, outpatient and inpatient treatments are limited, and although Brazil has approved emergency vaccines, it will take time to immunize the entire population. Therefore, behavioral measures, such as personal hygiene, wearing masks, healthy nutrition, and physical activity, are potential strategies in preventing or mitigating the disease.[3]

It is well known that exercise training (a subtype of physical activity) improves immune system response, protecting against infections caused by intracellular microorganisms.[4] For instance, regular exercise improves the pathogenic activity of tissue macrophages in parallel with an enhanced recirculation of immunoglobulins, anti-inflammatory cytokines, neutrophils, natural killer cells, cytotoxic T cells, and immature B cells, improving immune defense activity and healthy metabolism.[4] Several studies suggest that being physically active could protect or minimize the effects of COVID-19 in humans.[5] However, all of these studies have presented only physiological hypotheses that might explain such an association. Therefore, exercise training might be an important prevention strategy against SARS-CoV-2 and could play a key role in preventing hospitalizations and supporting faster recovery of infected patients.

The present study aimed to assess the association of physical activity before the pandemic and quarantine measures with the prevalence of hospitalizations in surviving patients infected with SARS-CoV-2 virus. Additionally, we investigated symptoms of the disease, length of hospital stay, and the use of mechanical ventilation in patients infected with SARS-CoV-2 and the association with sufficient and insufficient physical activity. We hypothesized that physically active patients diagnosed with COVID-19 have a lower number of hospitalizations compared with patients with insufficient levels of physical activity.

2. Methods

This study is registered on ClinicalTrials.gov (NCT04396353), and its protocol has been published previously.[6] This is a cross-sectional study comparing physical activity levels before the pandemic and quarantine measures of patients infected with SARS-Cov-2. This study was approved by the local Human Subject Protection Committee at the Hospital das Clinicas da Faculdade de Medicina da Universida de de São Paulo (CAPPesq 5044-20-073), and all participants provided an online written informed consent. We followed the STROBE statement checklist for cross-sectional studies.[7]

Between June 2020 and August 2020, we invited Brazilian survivors and fully recovered patients infected with SARS-CoV-2 between March and August 2020 to respond to an online questionnaire. We disclosed the electronic link of the form across the country through social media, newscasts, hospitals, medical care providers, and disease control centers in some cities. The questionnaire included questions regarding clinical outcomes (symptoms, medications, hospitalization, length of hospital stay, and mechanical ventilation) and cofactors like age, sex, ethnicity, preexisting diseases, socioeconomic and educational status. The short version of the International Physical Activity Questionnaire (IPAQ)[8] was used to collect data on physical activity levels before the outbreak and quarantine measures in surviving patients infected with SARS-CoV-2. The complete electronic questionnaire can be assessed in the Supplemental material.

The inclusion criteria were men and women who had recovered of the disease (outpatient without symptoms) and survivors after hospital discharge. Also included were individuals of all ages, with or without symptoms; patients with disease confirmed by a quantitative PCR viral test (qPCR), blood test (serology), and a rapid antibody test with or without hospitalization (nursery, semi-intensive and intensive unit care) and discharged from the hospital. Those with or without drug treatment, and with any chronic disease, such as diabetes, hypertension, coronary artery disease, obesity, metabolic syndrome, cancer, among others were also included. The exclusion criteria were illiterate patients who had difficulty filling out the electronic form and patients still hospitalized and with symptoms of COVID-19. In addition, after completing the form, some participants were excluded due to the quality control of the responses provided (see quality control below).

We collected a total of 1597 completed questionnaires, and all data were assessed to identify possible fraud and inappropriate responses. We identified 118 (7.4%) duplicate responses, which were excluded. Additionally, 277 (17.3%) participants who declared that they had been infected with the SARS-CoV-2 (because they believed they were sick) but without any diagnostic test and with or without symptoms were also excluded. Finally, only 2 children under 10 years of age answered the questionnaire, and we decided to exclude them from the sample (Fig. S1). After this first analysis of quality data responses, 1200 participants were selected.

The second part of the data quality control was to correlate the self-report of physical activity with the answers provided in the IPAQ questionnaire. In one part of the questionnaire, we asked how the participants declared themselves: “athlete,” “physically active,” or “sedentary.” These 3 categories were correlated with the amount of physical activity reported in the IPAQ questionnaire. For instance, if the participant declared him/herself as sedentary, but performed >150 min of physical activity per week, he/she was excluded (262 [21.8%] inconsistent answers). After this agreement, 938 (78.2%) out of 1200 were included in the final analysis (Fig. S1).

The participants were subdivided into 2 categories according to IPAQ information: sufficient physical activity (“athlete” and “physically active” were pooled) and insufficient physical activity (“sedentary”). Sufficient physical activity was considered when the participant performed at least 150 min per week of moderate physical activity and/or at least 75 min of vigorous physical activity.[9] Insufficient physical activity was defined when the participants did not meet these recommendations. In addition, sedentary behavior was defined considering the number of hours per day spent sitting in our cohort.[8]

Body mass index (BMI) was categorized as follows: underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), obesity I (30.0–34.9 kg/m^2), obesity II (35.0–40.0 kg/m^2), and obesity III (>40 kg/m^2).

The primary outcome of the study was to assess the number of hospitalizations among individuals with sufficient physical activity and insufficient physical activity who were infected with SARS-CoV-2. The secondary outcomes were to assess symptoms of the disease (such as fever, headaches and muscle aches, shortness of breath, cough, loss of taste or smell, fatigue/tiredness), length of hospital stay, and use of mechanical ventilation.

For the comparison of physical activity groups between the diagnoses of having or not having COVID-19, the sample was calculated based on the comparison of proportions in the G*Power software, with 80% power, 5% significance level, degree of freedom equal to 2 (following a 3×2 size table; 3 = hospitalization [yes and no] and 2 = physical activity [athlete, physically active, and sedentary]) and an effect size w of 0.1. The calculation of 964 participants with the addition of 10% of losses resulted in 1061. To answer the proposed objectives, the calculation with the largest sample size was considered.

The data analysis was performed using SPSS v.25 software. The distributions of the quantitative variables were verified by the Shapiro-Wilk normality test. Symmetric and asymmetric distribution variables

are presented as mean and standard deviation or median and interquartile range (median [p25 to p75]), respectively.

Categorical variables are represented by absolute and relative frequency. The sample characterization variables were associated with physical activity levels by using the chi-square test. The proportions of the variables were compared between the outcomes (hospitalization: yes or no) using the chi-square test. When significant, post-hoc analysis was performed using Winpepi v.11.65 software.

The Poisson regression model was used to estimate crude and adjusted prevalence ratios (PR) and their respective 95% CI. The statistical significance of the PR was assessed using Wald's statistics. Crude analysis of the variables was performed between the outcomes. After that, important multivariate outcomes were included in the model.

Among patients who were hospitalized, the association between physical activity levels and clinical variables of hospitalization (such as symptoms, medications, and mechanical ventilation) was analyzed. The distributions of length of hospital stay between physical activity levels were compared using the Mann-Whitney or Kruskal-Wallis test with the Dunn post-hoc test.

3. Results

Of 938 patients, 91 (9.7%) were hospitalized due to COVID-19. In a univariate analysis, sex, age, and BMI were associated with hospitalizations due to COVID-19. When degree of hospitalization was compared between men and women, men had a higher prevalence of hospitalization (66.6% [$p = 0.010$]). Patients older than 65 years had 7 times the prevalence of hospitalization compared with adults aged 18–39 years ($p < 0.001$). Patients with obesity I were hospitalized more than participants with normal weight ($p = 0.001$). When compared with normal weight patients, those overweight and obese patients had a higher prevalence of hospitalization between 83% and 166%. Preexisting disease ($p = 0.002$), 3 or more symptoms ($p < 0.001$), and using 2 or more medications ($p < 0.001$) were also factors associated with a higher prevalence of hospitalization (Table 1).

In a univariate analysis, patients with insufficient physical activity (mean = 62.3 ± 86.0 min/wk and median = 25.0 min/wk [0; 106]) had a higher degree of hospitalization compared with patients with sufficient physical activity (mean = 726.9 ± 426.7 min/wk and median = 640.0 min/wk [420; 925]). Those who were sufficiently active had a 37.6% lower prevalence of hospitalization due to COVID-19 (PR = 0.624; $p = 0.018$). Perform 2 or more physical activities had a reduction in the crude prevalence of hospitalization by 46.2% (Table 2).

Table S4 (Supplemental material) shows the characteristics between sufficient and insufficient physical activities. Men ($p = 0.010$), normal weight ($p < 0.001$), white race ($p = 0.031$), with >9 minimum wage (monthly salary) ($p < 0.001$), without medications ($p = 0.003$), and without preexisting diseases ($p < 0.001$) were all associated with sufficient physical activity. On the other hand, women, obesity I, II, and III, non-white race, <3 minimum wages (monthly salary), 3 or more medications, and 1 or more preexisting diseases were associated with insufficient physical activity.

Table 1
Characterization of the sample, comparison of proportions and calculation of the crude prevalence ratio of the variables in patients with COVID-19.

	Total $n = 938$	Patients admitted to the hospital due to COVID-19 $n = 91$ (9.7%)	Chi-square test	Univariable Poisson regression		
			P*			
	n (%)	n (%)		PR	[95%CI]	P†
Sex						
Men	328 (35)	43 (13.1)	**0.013**	1.666	[1.129;2.458]	**0.010**
Women	610 (65)	48 (7.9)		ref		
Age (years) (missing = 1)						
<18	6 (0.6)	0 (0)a	<**0.001**	–		
18–39	532 (56.8)	40 (7.5)a		ref		
40–64	382 (40.8)	42 (11)a		1.462	[0.968;2.209]	0.071
65–80	17 (1.8)	9 (52.9)b		7.041	[4.111;12.061]	<**0.001**
BMI (kg/m^2) (missing = 5)						
Underweight	9 (1)	2 (22.2)	**0.003**	3.848	[1.062;13.950]	**0.040**
Normal weight	381 (40.9)	22 (5.8)a		ref		
Overweight	340 (36.4)	36 (10.6)		1.834	[1.101;3.053]	**0.020**
Obesity I	130 (13.9)	20 (15.4)b		2.664	[1.504;4.720]	**0.001**
Obesity II and III	73 (7.8)	11 (15.1)		2.610	[1.323;5.146]	**0.006**
Race						
White	676 (72.1)	64 (9.5)	0.790	ref		
Nonwhite	262 (27.9)	27 (10.3)		1.089	[0.711;1.668]	0.697
Education						
High school or more	897 (95.6)	85 (9.5)	0.277	ref		
Incomplete elementary or high school	41 (4.4)	6 (14.6)		1.544	[0.718; 3.324]	0.267
Family income (monthly minimum wage)						
<1	23 (2.5)	1 (4.3)	0.680	0.312	[0.043; 2.293]	0.253
1 to 3	218 (23.2)	23 (10.6)		0.758	[0.387;1.482]	0.418
3 to 5	181 (19.3)	17 (9.4)		0.675	[0.331;1.373]	0.278
5 to 7	140 (14.9)	11 (7.9)		0.564	[0.256;1.242]	0.155
7 to 9	79 (8.4)	11 (13.9)		ref		
>9	297 (31.7)	28 (9.4)		0.677	[0.353;1.299]	0.241
Smoker						
No	892 (95.1)	85 (9.5)	0.440	ref		
Yes	46 (4.9)	6 (13)		1.369	[0.632;2.965]	0.426
Pre-existing diseases						
Without diseases	554 (59.1)	40 (7.2)a	**0.002**	ref		
With diseases	384 (40.9)	51 (13.3)b		1.839	[1.242;2.725]	**0.002**
Number of symptoms						
From 0 to 2	276 (29.4)	10 (3.6)a	<**0.001**	ref		
3 or more	662 (70.6)	81 (12.2)b		3.377	[1.778;6.416]	<**0.001**

Note: different letters represent statistically different proportions. Bold emphasis was used to highlight statistical significance.
* Chi-square test.
† Unadjusted regression; PR = prevalence ratio; 95%CI = 95% confidence interval.

Table 2
Physical activity level, comparison of proportions and calculation of the crude prevalence ratio of the variables in relation to patients hospitalized by COVID-19.

	Total n = 938	Patients admitted to the hospital due to COVID-19	Chi-square test	Univariable Poisson regression		
		n = 91 (9.7%)	P*			
	n (%)	n (%)		PR	[95%CI]	P†
Physical activity (>150 min/wk [moderate] and/or 75 min/wk [vigorous])						
Sufficient	611 (65.1)	49 (8)a	**0.024**	1		
Insufficient	327 (34.9)	42 (12.8)b		0.624	[0.423; 0.922]	**0.018**
Sitting time in hours/day						
<4.7 h/day	463 (49.4)	51 (11)	0.218	ref		
≥4.7 h/day	475 (50.6)	40 (8.4)		1.308	[0.882; 1.939]	0.181
Sitting time in hours/day						
<7.4 h/day	710 (75.7)	72 (10.1)	0.501	ref		
≥7.4 h/day	228 (24.3)	19 (8.3)		1.217	[0.751;1.972]	0.426
Number of physical activities performed						
2 or more	261 (27.8)	36 (7.4)a	**0.020**	0.538	[0.348;0.833]	**0.005**
1	192 (20.5)	19 (9.9)		0.717	[0.425;1.211]	0.214
None	485 (51.7)	36 (13.8)b		ref		

Note: different letters represent statistically different proportions. Bold emphasis was used to highlight statistical significance.
* Chi-square test.
† Unadjusted regression (crude).

Table 3 shows the multivariate regression model to predict the factors involved in the primary outcome. Model 1 (adjusted for age and sex) showed a significant association of lower prevalence of hospitalization in patients with sufficient physical activity: >150 min/wk (moderate) and/or >75 min/wk (vigorous) (PR = 0.602; $p = 0.009$). Interestingly, >150 min/wk (moderate) and/or >75 min/wk (vigorous) physical activity was independently associated with a lower prevalence of hospitalizations in model 2 (adjusted for age, sex, and BMI, PR = 0.642; $p = 0.028$) and model 3 (adjusted for age, sex, and preexisting diseases, PR = 0.657; $p = 0.046$).

Tables S5 and S6 (Supplemental materials) show the comparison among hospitalized patients regarding intubation, oxygen therapy, length of hospital stay, symptoms, and medications used. Notably, there were no significant differences between these clinical outcomes in the comparison between the different physical activity levels.

4. Discussion

The present study aimed to assess the association of physical activity before the pandemic and quarantine measures with the prevalence of hospitalizations in surviving patients infected with SARS-CoV-2 virus. The main finding is that sufficient physical activity decreases the prevalence of COVID-19-related hospitalization. The main finding of the present study is the independent association between levels of physical activity and COVID-19-related hospitalization. Interestingly, performing at least 150 min a week of moderate-intensity, or 75 min a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity, was associated with a 34.3% lower prevalence of hospitalization due to COVID-19 (PR = 0.657; $p = 0.046$). However, physical activity had no additional protection among those patients who were hospitalized. There was no difference in the prevalence of intubation, oxygen therapy, symptoms, and length of hospital stay between physically active and inactive patients.

Observational studies have investigated the association between functional capacity parameters and COVID-19 outcomes. In a specific sample including patients with clinical indications for exercise testing, maximal exercise capacity determined from an exercise test before SARS-CoV-2 infection was independently and inversely associated with the likelihood of COVID-19-related hospitalization (adjusted OR, 0.87; 95% CI, 0.76–0.99). Each unit higher of peak METs was independently associated with 13% lower odds of hospitalization.[10] Recently, a simple measure of self-reported walking pace was used to assess physical fitness in COVID-19 patients in a retrospective study. Compared to those with a brisk walking pace, the OR of severe COVID-19 for slow walkers was 1.88 (1.53, 2.31).[11] The findings of the present study corroborate the previous evidence. A difference of our experiment is that the habits reported about physical activity are more recent since they refer to the period immediately before the pandemic and SARS-CoV-2 infection. In addition, the measurement instrument used (IPAQ short form) allowed us to use cutoff points according to recommendations of WHO on physical activity, facilitating the clinical interpretation of our findings.

Table 3
Poisson multivariate regression model.

	Model 1			Model 2			Model 3		
	PR	[CI 95%]	P	PR	[CI 95%]	P	PR	[CI 95%]	P
Physical activity (>150 min/wk [moderate] and/or 75 min/wk [vigorous])									
Sufficient	0.602	[0.411;0.883]	**0.009**	0.642	[0.432;0.954]	**0.028**	0.657	[0.435;0.992]	**0.046**
Insufficient	ref			ref			ref		
Sitting time in hours/day									
<4.7	1.179	[0.798;1.743]	0.408	1.266	[0.851;1.883]	0.244	1.241	[0.836;1.841]	0.284
≥4.7	ref			ref			ref		
Sitting time in hours/day									
<7.4	1.092	[0.679;1.758]	0.716	1.133	[0.704;1.822]	0.608	1.141	[0.709; 1.838]	0.586
≥7.4	ref			ref			ref		

Model 1: adjusted for age (continuous) and sex.
Model 2: adjusted for age (continuous), sex, and BMI (continuous).
Model 3: adjusted for age (continuous), sex, and pre-existing diseases (yes or no). Bold emphasis was used to highlight statistical significance.

In Brazil, to date, the COVID-19 outbreak led to over 378 thousand death with a higher incidence of hospitalizations. Approximately 7% of confirmed cases (>1 million patients) required hospital care. This burden has a high public health impact with an estimated cost of US$ 13,000 for less severe patients and US$ 40,000 for more severe patients with ventilator support.[12] Several studies have shown that obesity, preexisting diseases, and advanced age are important predictors of the severity of COVID-19.[13] Our study extends the knowledge that physical activity is a marker of hospitalization prediction after adjusting for these cofactors.

The prevalence of insufficient physical activity was lower in this study (34.9%) compared with previous study of the Brazilian adult population (47%).[14] It is possible that the observed difference can be attributed to the recruitment process through electronic sources, restricting access to a specific portion of the population. We also observed a lower prevalence of hospitalization compared with some previous studies,[10,15,16] which is probably influenced by the high level of physical activity in the sample of the present study, a hypothesis reinforced by our association findings. Furthermore, it is important to highlight that the present study involved institutions from different Brazilian states with a national coverage.

In the present study, we observed the higher prevalence of hospitalization in older patients, which could be explained by the association of systemic inflammation (termed "inflammaging[17]") in elderly people. Interestingly, exercise training attenuates aging biomarkers and modulates the redox balance.[12] Master athletes have better redox balance and inflammatory status compared with middle age-matched controls.[18] Thus, physical activity may be a strategy to prevent clinical severity in elderly persons with COVID-19.

Obesity has been associated with insufficient physical activity and sedentary behavior.[19–22] Indeed, we found a higher proportion of obese patients with insufficient physical activity. Inflammation has been described as a key mechanism in the worsening of COVID-19 in the obese.[23,24] Interestingly, physical activity is recommended as part of weight loss for obese adults (Evidence Category A).[20,25,26] In addition, physical activity is one of the nonpharmacological therapies to reduce inflammatory cytokines,[27] which may be a possible mechanism of protection in patients infected with SARS-CoV-2. It has been suggested that central obesity compromises lung ventilation and may exacerbate COVID-19.[28] Increased abdominal obesity[29] and obstructive sleep apnea[30] are common conditions in obesity, and both are remarkably improved after an exercise training program.[20,25]

Physical activity improves immune system response mainly due to the amelioration of recirculation of immunoglobulins, neutrophils, natural killer cells, cytotoxic T cells, and immature B cells.[4] Additionally, exercise prevents and treats numerous COVID-19-associated complications, such as cardiac, neurological, and metabolic disorders,[22,31] including the positive effect on the renin-angiotensin system.[32–34] Interestingly, acute and chronic exercise training promote changes in immune system.[35] In fact, while one session of exercise changes most immunological markers such as CD16-56 NK cells, chronic exercise interferes with a smaller proportion, this being in lymphocyte subpopulations like CD4+, CD8+, and CD20.[35] Future studies are needed to better understand the mechanisms involved in physical activity and its benefits in patients with COVID-19.

This is an observational study and the results should be interpreted with caution. Although we found an association between physical activity and lower prevalence of COVID-19-related hospitalizations, we did not investigate the mechanisms involved in this relationship. All participants filled out the electronic form by themselves and possible bias should be considered. However, we constructed a quality control criterion to reduce such biases. We did not directly measure physical activity by an accelerometer device; however, self-report physical activity questionnaires have been largely used in research, and a systematic review shows that the IPAQ shortform has excellent test–retest reliability ($r = 0.91$).[36] Considering that data collection occurred during the pandemic, it is possible that some individuals have changed their physical activity habits as a result of the preventive measures and reported their physical activity habits during this period.

5. Conclusion

Sufficient physical activity is associated with a lower prevalence of COVID-19-related hospitalizations. Performing at least 150 min a week of moderate-intensity, or 75 min a week of vigorous-intensity physical activity represented 34% lower prevalence of COVID-19-related hospitalizations. Public policies should encourage regular physical exercise to prevent complications from COVID-19.

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Declaration of interest statement

The authors declare that there is no conflict of interest.

Confirmation of ethical compliance

This study was approved by the local Human Subject Protection Committee at the Hospital das Clinicas da Faculdade de Medicina da Universidade de São Paulo (CAPPesq 5044-20-073), and all participants provided an online written informed consent.

This study is registered on ClinicalTrials.gov (NCT04396353), and its protocol has been published previously (https://osf.io/crv6t).

Data sharing

All data are shared publicly through the tool Open Science Framework (https://osf.io/crv6t).

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