Monaldi Archives for Chest Disease

eISSN 2532-5264 https://www.monaldi-archives.org/

Monaldi Arch Chest Dis 2023 [Online ahead of print]

To cite this Article:
Ribeiro Neto F, Machado MarquesJ, Brasiliano da Paz M, et al. **Sit to stand test and handgrip strength in men and women with post-COVID-19 syndrome without invasive ventilator support: insights from a Brazilian observational study.** *Monaldi Arch Chest Dis* doi: 10.4081/monaldi.2023.2495

Sit to stand test and handgrip strength in men and women with post-COVID-19 syndrome without invasive ventilator support: insights from a Brazilian observational study

Frederico Ribeiro Neto, Juliane Machado Marques, Matheus Brasiliano da Paz, Eduardo Boiteux Uchôa Cavalcanti, Rodrigo Rodrigues Gomes Costa

SARAH Network of Rehabilitation Hospitals, Brasilia, Brazil

Corresponding author: Professor Frederico Ribeiro Neto, Paralympic Sports Program, SARAH Rehabilitation Hospital Network, SQN 416 BL K Ap 106, Brasilia, Brazil.
Mob: 55 61 99184-1550
Email: fredribeironeto@gmail.com

Acknowledgments: The authors are grateful to the Physical Education staff of the SARAH Network of Rehabilitation Hospitals.

Contributions: FRN, JMM, RRGC: study conception, design, and methodology; FRN, JMM, MBP: data collection; FRN: data analysis and interpretation; FRN, JMM: manuscript writing (first draft); FRN, JMM, RRGC, MBP, EUC: editing and critical review of the manuscript. All the authors have read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Conflict of interest: We certify that no party has a direct interest in the results of the research supporting this article or has or will confer a benefit on us or on any organization with which we are associated.

Funding: None.

Ethics approval and consent to participate: The study was approved by the institutional ethics committee (protocol n. 5.123.622), and all participants provided written informed consent.

Availability of data and materials: Data can be provided upon reasonable request.

Abstract

Two valid tests have been used in patients with post-COVID-19 syndrome (coronavirus disease 2019) due to their fast application, feasibility, and accessible procedures, facilitating data collection in large groups: the 1-minute sit-to-stand test (STS) and handgrip strength (HGS) dynamometry. The present study aimed to: i) Assess the STS and HGS in men and women with post-COVID-19 syndrome who did not require invasive ventilator support; ii) Correlate STS repetitions and HGS with time since the COVID-19 diagnosis. Six hundred and twenty-two men and women with post-COVID-19 syndrome who did not require invasive ventilatory support performed the STS and HGS tests at the beginning of the rehabilitation process at a Reference Hospital Centre. Women over 55 years presented significantly lower results compared to participants under 55 years. For the HGS, the median ranged from 42 to 48 kg and 70 to 81 kg for the female and male groups, respectively. The correlations of time since COVID-19 diagnosis with STS and HGS ranged from -0.16 to 0.02 ($p>0.05$) for women and men, respectively.The test results could be used for the initial analysis of normality ranges and comparisons with other populations. Although STS repetitions and HGS presented low and non-significant correlations with time since the COVID-19 diagnosis, some COVID-19 sequelae were not measured, so these data should be interpreted with caution.

Keywords: physical fitness; muscle strength; muscle strength dynamometer; task performance and analysis; rehabilitation

Introduction

The coronavirus disease 2019 (COVID-19) is a systemic infection that causes acute respiratory syndrome and dysfunction in several organs [1]. Up until November 2022, more than 635 million people had been diagnosed with COVID-19 and an additional 6.6 million had died from this infection [2]. In addition to the physiological consequences, a high prevalence of physical performance impairment has been reported in COVID-19 survivors [3,4]. The terms 'Long COVID' or 'Post-COVID' are commonly used to describe an array of signs and symptoms that are present after acute COVID-19 [5]. The UK's National Institute for Health and Care Excellence described long COVID-19 as "ongoing symptomatic COVID-19" (symptoms between 4 and 12 weeks) and "post-COVID-19 syndrome" as symptoms lasting longer than 12 weeks [6] COVID-19 survivors (without hospitalization) have reported post-COVID syndrome and the most frequent alterations found are headache, balance and coordination disorders, attention difficulty, insomnia, changes in taste and smell, depression, anxiety, physical and nutritional dysfunctions [5], executive function problems, and anxiety/depression [7].

In addition, several musculoskeletal alterations such as myalgia, arthralgia, and muscle fatigue were also reported as sequelae after COVID-19 [8,9]. These symptoms are important since muscle strength is an indicator of muscle function, essential for health [10,11], and is a robust predictor of various diseases and mortality [10,12]. Likewise, cardiovascular capacity is associated with improved physical performance and functional capacity, and reduced cardiac risks [13,14] and cardiopulmonary changes were reported after COVID-19 [15]. Overall, the impact of post-COVID-19 syndrome should be considered as the potential cause of a delayed pandemic that may have a major public health impact in the medium to long term [5]. Even after the pandemic, the involvement of specific health professionals is needed, in order to manage and care for an increased number of patients. Thus, evaluating muscle strength, and functional and cardiorespiratory capacity in post-COVID-19 syndrome patients is important to estimate functional implications, impairments, and desaturation on exertion [16,17].

Among the strength and functional capacity assessments, two validated tests have been used in post-COVID-19 syndrome patients as they are fast, feasible, and accessible procedures, facilitating data collection in large groups: the 1-minute sit-to-stand test (STS) [18,19] and handgrip strength (HGS) dynamometry [20,21]. The STS has been used, among other analyses, to measure oxygen desaturation evaluate [3,18], telerehabilitation outcomes [22], and after hospitalization [23]. Recent studies have related HGS to injury severity [24] and a lower risk of hospitalization [25], in addition to being used in longitudinal studies to assess intervention outcomes [20].

These tests have been frequently performed and used for different outcome analyses in post-COVID-19 syndrome patients. However, the values of these tests in such patients are not known, which limits our ability to determine expected ranges and make comparisons with other populations. Additionally, the sequelae of COVID-19 differ visibly between patients who did or did not require invasive ventilatory support, which affects the homogeneity of values for comparisons. [26,27]. Therefore, considering that most post-COVID-19 syndrome individuals did not require invasive ventilator support [26,28] the present study aimed to evaluate the 1-minute sit-to-stand test and handgrip tests in men and women with this diagnosis. A second objective was to correlate the time since the COVID-19 diagnosis with STS repetitions and HGS. We hypothesized that 1) values of STS and HGS would be determined for male and female post-COVID-19 syndrome patients who did not require critical care and, 2) STS repetitions and HGS would correlate positively and significantly with time since the COVID-19 diagnosis.

Methods

Participants

This retrospective observational study included six hundred and twenty-two men and women with post-COVID-19 syndrome who did not require invasive ventilator support and participated in outpatient rehabilitation at a Network Centre of Rehabilitation Hospitals (Table 1). Data were collected from April 2021 to June 2022. The study was approved by the institutional ethics committee, and all participants provided written informed consent.

Inclusion criteria were: 1) previously confirmed SARS-CoV-2 PCR with symptoms of post-COVID-19 syndrome, such as general fatigue, respiratory fatigue, and muscle or joint pain that are not explained by alternative diagnoses [2,29], and 2) adult individuals (from 18 years old) of both sexes. Participants were excluded if they: 1) used invasive ventilator support for COVID-19 recovery, 2) presented upper or lower limb injury or disabling pain that could hamper test performance, 3) used orthosis or prosthesis, and 4) presented medical records with incomplete data or with registration errors (Figure 1).

Procedures

Men and women with post-COVID-19 syndrome who did not require ventilator support performed the STS and HGS tests at the beginning of the rehabilitation process at a Network Centre of Rehabilitation Hospitals.

1-minute sit-to-stand test (STS)

The test was performed using a chair of standard height (46 cm) without armrests, positioned against a wall. The participants were not allowed to use their hands/arms to push the seat of the chair or their body (arms crossed over the chest). The evaluator explained the test execution technique and instructed the participants to complete as many sit-to-stand cycles (repetitions, reps) as possible in 60 seconds at a self-paced speed. Prior to the test, one repetition was performed for familiarization and possible corrections. The participants started the test sitting, with their back to the chair, and were required to stand up until full extension of hips and knees and sit down until touching their hip on the chair. The evaluator counted each complete movement cycle (sitting, standing, and returning to the sitting position) aloud and informed the participant when 10 seconds were remaining. No verbal stimulus or encouragement was given during the test, but reminders were provided to stand up fully [30].

Handgrip strength assessment (HGS)

Handgrip strength was measured using a hand dynamometer (Saehan Corporation) with participants seated, shoulder adducted, elbow flexed to 90°, wrist in a neutral position, and the medial phalanges of the hand resting on the dynamometer handle. Participants then exerted maximum HGS three times for each hand, alternately between hands, and rested for 1 minute between attempts. After each attempt, the participant was informed about the result to motivate them for the next effort. The final result was the sum of the highest measures for the left and right sides [31].

Main outcomes

The total number of repetitions of the STS and the sum of the highest measures of the HGS (kgf) were the primary outcomes and were used to determine the values. The time since the COVID-19 diagnosis was correlated with STS repetitions and HGS.

Statistical analysis

The Kolmogorov-Smirnov normality test was used to analyze data distribution. Descriptive data were expressed as median and interquartile ranges (25th and 75th percentiles) for the nonparametric outcomes, and the Mann-Whitney U test was used to compare groups (male and female).

Percentile tables were constructed and classified as follows: poor (below the 10^{th} percentile), fair (25^{th} percentile), average (50^{th} percentile), good (75^{th} percentile), and excellent (above the 90^{th} percentile). The Kruskal Wallis test with Mann-Whitney *posthoc* test was used to compare the age range for male and female groups (under 45.0 years, 45.0 to 55 years, and over 55.0 years). Age stratification into three groups was established *a posteriori* so that an effect size of 0.30, α of 5%, and power (1 - β) of 90% were achieved for group comparisons, considering the sample size of the smallest group (male, n=145).

The Spearman's test was applied to correlate the time since the COVID-19 diagnosis with STS repetitions and HGS. Correlation coefficient values were classified as very weak (below 0.20); weak (0.20 to 0.39); moderate (0.40 to 0.69); high (0.70 to 0.90); and very high (>0.90).

The outlier labeling rule was used to detect outliers and discrepancies. Outlier values were calculated by the difference between the 25^{th} and 75^{th} percentiles, multiplied by a factor of 2.2. The result was then subtracted from the 25^{th} percentile and added to the 75^{th} percentile.

The IBM SPSS Statistics package (version 22.0, NY, US), and G*Power statistical power analysis software (version 3.1.9.2; Germany) were used. Statistical significance was set at 5% ($P \leq 0.05$; two-tailed).

Results

Sample characteristics

The study analysis included 622 out of 647 participants (96.1%) who completed the STS and HGS. The sample consisted of 76.7% women and 50% of all participants presented ages ranging from 41.0 to 57.3 years (percentiles 25 and 75). The female group presented significantly lower age (48.0 vs. 52.0 years), and height (160.0 cm vs. 173.0 cm) than the male group (Table 1 and Figure 1).

Test results

The STS and HGS results were shown in Table 2. The median repetitions of STS for the female group ranged from 16 to 20. The female group “over 55 years” presented significantly lower repetitions compared to the two groups under 55 years. There were no significant differences in the STS repetitions between age stratifications of the male group (median ranging from 20 to 23 reps) (Table 2 and Figure 2A). For the HGS, both female groups under 55 years showed significantly higher strength compared to the “over 55.0 years” group. The male “under 43 years” group presented significantly higher strength compared to the two groups over 43 years.

The median ranged from 42 to 48 kgf and 70 to 81 kgf for female and male groups, respectively (Table 2 and Figure 2B).

Correlations

The correlations of time since COVID-19 diagnosis with STS reps and HGS were not significant and classified as very weak for women and men (rho ranging from -0.16 to 0.02, $p>0.05$) (Table 3).

Discussion

The present study evaluated the STS reps and HGS in men and women with post-COVID-19 syndrome who did not require invasive ventilator support. These values could be used for the initial analysis of normality ranges and comparisons with other populations. The main findings revealed higher performance for STS reps and HGS in men and women under 45 years (no statistical difference for STS in the male group). In addition, very low and non-significant correlations between time since the COVID-19 diagnosis with STS repetitions and HGS were verified. However, the severity of general fatigue, respiratory fatigue, and muscle or joint pain of the participants were not measured, so these data should be interpreted with caution.

The present study demonstrated that the post-COVID-19 syndrome age groups presented less than 50% of the reps compared to healthy population-based reference values [32] for females and males as observed in Table2 and Figure 2. However, the results of the healthy population [32] were also higher than patients on hemodialysis (ranging from 17 to 26 reps) [33,34], with chronic obstructive pulmonary disease (ranging from 15 to 24 reps) [35–37] with stroke (10 reps) [38] with end-stage and palliative care (ranging from 17 to 21 reps) [39,40] women with postmenopausal osteoporosis (26 reps), older adults (35 and 27 reps for males and females, respectively) [41] and healthy adults (ranging from 20 to 24 reps) [35,42,43]. Regarding previous STS results with COVID-19 samples, studies with patients recovering from COVID-19 pneumonia (mean age of 63 years, 21 reps) [18] use of oxygen (mean age of 74 years, 9 reps) [19] and with post-COVID-19 syndrome symptoms (mean age of 62 years, 16 reps) [22] demonstrated large variability in scores. The heterogenicity of the results is dependent on age, sex, and COVID-19 symptoms, and emphasizes the importance of the present results.

The HGS is one of the simplest and most practical instrumented muscle strength assessments. In addition, the clinical importance of the HGS is also supported by its association with other concurrent clinical measures (i.e., nutritional, muscle mass, function, and health status) in middle-aged and older adults [44]. The present study presented HGS results for men and women with post-COVID-19 syndrome who did not require ventilator support. According to previous studies and preliminary analyses, people with some chronic conditions have significantly lower grip strength compared with their healthy peers [45,46]. However, regarding previous HGS reference values, overall the present sample demonstrated similar HGS results compared to Brazilian (40 to 49 years and median HGS of 81.4 and 52.3 kgf; Figure 2) [47], Canadian (45 to 49 years and median HGS of 48.1 and 28.3 kgf in the dominant hand) [48], Australian (40 to 49 years and mean HGS of 92.0 and 57.0 kgf) [49], and Nigerian (40 to 49 years and median HGS of 63.5 and 41.0 kgf) [50] male and female healthy adults, respectively.

Considering other COVID-19 samples, the present study demonstrated higher HGS compared to patients in an intensive care unit with mechanical ventilation (55 to 67 years, median HGS of 8.0 and 0.0 kgf in the dominant hand for males and females, respectively) [33] and patients after the acute phase (mean age of 69 years, mean HGS of 21.1 and 16.4 kgf in the dominant hand for male and female, respectively) [34]. However, studies with non-hospitalized patients (mean age of 69 years, mean HGS of 34.5 kgf in the dominant hand) [32] and non-severe hospitalized adults (40 to 49 years, median HGS of 78.7 and 48.4 kgf for male and female, respectively) [31] presented an HGS analogous with our sample.

In fact, very weak and no significant correlations were obtained for the time since COVID-19 diagnosis with STS and HGS for men and women. Probably, post-COVID-19 syndrome patients who did not require invasive ventilator support and hospitalization did not present a significant decline in functional performance in the acute phase of the disease. A second possible reason for the very weak correlations might be related to the heterogeneity of symptoms and sequelae of COVID-19 [35,36]. These findings are consistent with a recent study where the length of stay presented a weak correlation with STS with no statistical significance. Although the present study assessed individuals who did not require ventilator support to increase the homogeneity of the sample and reduce confounders in the analysis of the results, the heterogeneity of the severity of each COVID-19 sequela and other interventions as physiotherapy were not controlled and might have interfered with the final correlation results. Conducting further studies to investigate the correlation between symptoms and interventions with STS and HGS scores may provide valuable insights into the relationship between these variables.

Study limitations

The first limitation of this study is the lack of control over non-invasive ventilation or oxygenation strategies, the lack of knowledge of the severity of the disease and the comorbidities of the patients in the sample. These factors introduce a potential source of variability in the study results and these interventions can have a significant impact on patient outcomes. Although our study provides valuable information about STS in individuals with post-COVID-19 syndrome, caution should be exercised when interpreting the results reported, as fatigue and muscle strength measurements were not included. Therefore, the performance test correlations with time since the COVID-19 diagnosis might be underestimated if participants presented reduced complaints during assessments. Future studies that incorporate physical function tests, such as gait speed, balance, and functional mobility assessments, could provide a more comprehensive understanding of the functional status of individuals with post-COVID-19 syndrome.

Conclusions

The STS and HGS were evaluated in men and women with post-COVID-19 syndrome who did not require invasive ventilator support. These values could be used for the initial analysis of normality ranges and comparisons with other populations. The findings also showed that there were weak and non-significant correlations between the duration of COVID-19 diagnosis and the tests. It is important to note that the severity of general fatigue, respiratory fatigue, and muscle or joint pain experienced by the participants were not assessed, which could potentially impact the interpretation of the results. Therefore, caution should be exercised when interpreting these findings. The established results for post-COVID-19 syndrome contribute to preventive interventional approaches, mitigating social impact as an integral part of the response to the pandemic.

References

1. Barazzoni R, Bischoff SC, Breda J, et al. ESPEN expert statements and practical guidance for nutritional management of individuals with SARS-CoV-2 infection. Clin Nutr 2020;39:1631-8.
2. World Health Organization. WHO Coronavirus (COVID-19) Dashboard. 2021. Available from: https://covid19.who.int/
3. Paneroni M, Simonelli C, Saleri M, et al. Muscle strength and physical performance in patients without previous disabilities recovering from COVID-19 pneumonia. Am J Phys Med Rehabil 2021;100:105-9.

4. World Health Organization. A clinical case definition of post COVID-19 condition by a Delphi consensus, 6 October 2021. Available from: https://www.who.int/publications/i/item/WHO-2019-nCoV-Post_COVID-19_condition-Clinical_case_definition-2021.1
5. Crispo A, Bimonte S, Porciello G, et al. Strategies to evaluate outcomes in long-COVID-19 and post-COVID survivors. Infect Agent Cancer 2021;16:62.
6. Shah W, Hillman T, Playford ED, Hishmeh L. Managing the long term effects of covid-19: summary of NICE, SIGN, and RCGP rapid guideline. BMJ 2021;372:n136.
7. Braga LW, Oliveira SB, Moreira AS, et al. Neuropsychological manifestations of long COVID in hospitalized and non-hospitalized Brazilian patients. NeuroRehabilitation 2022;50:391-400.
8. Chen G, Wu D, Guo W, et al. Clinical and immunological features of severe and moderate coronavirus disease 2019. J Clin Invest 2020;130:2620-9.
9. Schett G, Manger B, Simon D, Caporali R. COVID-19 revisiting inflammatory pathways of arthritis. Nat Rev Rheumatol 2020;16:465-70.
10. Leong DP, Teo KK, Rangarajan S, et al. Prognostic value of grip strength: findings from the Prospective Urban Rural Epidemiology (PURE) study. Lancet 2015;386:266-73.
1. Wolfe RR. The underappreciated role of muscle in health and disease. Am J Clin Nutr 2006;84:475-82.
2. Celis-Morales CA, Welsh P, Lyall DM, et al. Associations of grip strength with cardiovascular, respiratory, and cancer outcomes and all cause mortality: prospective cohort study of half a million UK Biobank participants. BMJ 2018;361:k1651.
3. Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults. Circulation 2007;116:1094-105.
4. Riebe D, Franklin BA, Thompson PD, et al. Updating ACSM's recommendations for exercise preparticipation health screening. Med Sci Sports Exerc 2015;47:2473-9.
5. Torres-Castro R, Vasconcello-Castillo L, Alsina-Restoy X, et al. Respiratory function in patients post-infection by COVID-19: a systematic review and meta-analysis. Pulmonology 2021;27:328-37.
6. Belli S, Balbi B, Prince I, et al. Low physical functioning and impaired performance of activities of daily life in COVID-19 patients who survived hospitalisation. Eur Respir J 2020;56:2002096.
7. Simonelli C, Paneroni M, Fokom A, et al. How the COVID-19 infection tsunami revolutionized the work of respiratory physiotherapists: an experience from Northern Italy. Monaldi Arch Chest Dis 2020;90:1085.
8. Núñez-Cortés R, Rivera-Lillo G, Arias-Campoverde M, et al. Use of sit-to-stand test to assess the physical capacity and exertional desaturation in patients post COVID-19. Chron Respir Dis 2021;18:1-7.
9. Zampogna E, Migliori GB, Centis R, et al. Functional impairment during post-acute COVID-19 phase: Preliminary finding in 56 patients. Pulmonology 2021;27:452-5.
10. Hoyois A, Ballarin A, Thomas J, et al. Nutrition evaluation and management of critically ill patients with COVID-19 during post–intensive care rehabilitation. JPEN J Parenter Enteral Nutr 2021;45:1153-63.
11. Gobbi M, Brunani A, Arreghini M, et al. Nutritional status in post SARS-Cov2 rehabilitation patients. Clin Nutr 2022;41:3055-60.
12. Martin I, Braem F, Baudet L, et al. Follow-up of functional exercise capacity in patients with COVID-19: It is improved by telerehabilitation. Respir Med 2021;183:106438.
13. Baricich A, Borg MB, Cuneo D, et al. Midterm functional sequelae and implications in rehabilitation after COVID-19: a cross-sectional study. Eur J Phys Rehabil Med 2021;57:199-207.

14. Tuzun S, Keles A, Okutan D, et al. Assessment of musculoskeletal pain, fatigue and grip strength in hospitalized patients with COVID-19. Eur J Phys Rehabil Med 2021;57:653-62.
15. Cheval B, Sieber S, Maltagliati S, et al. Muscle strength is associated with COVID-19 hospitalization in adults 50 years of age or older. J Cachexia Sarcopenia Muscle 2021;12:1136-43.
16. Pérez-González A, Araújo-Ameijeiras A, Fernández-Villar A, et al. Long COVID in hospitalized and non-hospitalized patients in a large cohort in Northwest Spain, a prospective cohort study. medRxiv 2021.08.05.21261634.
17. Bergquist S, Partin C, Roberts DL, et al. Non-hospitalized adults with COVID-19 differ noticeably from hospitalized adults in their demographic, clinical, and social characteristics. SN Compr Clin Med 2020;2:1349-57.
18. Richardson S, Hirsch JS, Narasimhan M, et al. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. J Am Med Asso. 2020;323:2052-9.
19. The Lancet. Facing up to long COVID. Lancet 2020;396:1861.
20. Bohannon R, Crouch R. 1-minute sit-to-stand test: systematic review of procedures, performance, and clinimetric properties. J Cardiopulm Rehabil Prev 2019;39:2-8.
21. American College of Sports Medicine. ACSM’s guidelines for exercise testing and prescription. 9th ed. Lippincott Williams & Wilkins, 2013. 456 p.
22. Strassmann A, Steurer-Stey C, Lana KD, et al. Population-based reference values for the 1-min sit-to-stand test. Int J Public Health 2013;58:949-53.
23. Segura-Ortí E, Martínez-Olmos F. Test-retest reliability and minimal detectable change scores for sit-to-stand-to-sit tests, the six-minute walk test, the one-leg heel-rise test, and handgrip strength in people undergoing hemodialysis. Phys Ther 2011;91:1244-52.
24. Majchrzak KM, Pupim LB, Chen K, et al. Physical activity patterns in chronic hemodialysis patients: comparison of dialysis and nondialysis days. J Ren Nutr 2005;15:217-24.
25. Zanini A, Aiello M, Cherubino F, et al. The one repetition maximum test and the sit-to-stand test in the assessment of a specific pulmonary rehabilitation program on peripheral muscle strength in COPD patients. Int J Chron Obstruct Pulmon Dis 2015;10:2423-30.
26. Rausch-Osthoff AK, Kohler M, Sievi NA, et al. Association between peripheral muscle strength, exercise performance, and physical activity in daily life in patients with chronic obstructive pulmonary disease. Multidiscip Respir Med 2014;9:37.
27. Vaidya T, de Bisschop C, Beaumont M, et al. Is the 1-minute sit-to-stand test a good tool for the evaluation of the impact of pulmonary rehabilitation? Determination of the minimal important difference in COPD. Int J Chron Obstruct Pulmon Dis 2016;11:2609-16.
28. Britton E, Harris N, Turton A. An exploratory randomized controlled trial of assisted practice for improving sit-to-stand in stroke patients in the hospital setting. Clin Rehabi. 2008;22:458-68.
29. Low J, Davis S, Drake R, et al. The role of acceptance in rehabilitation in life-threatening illness. J Pain Symptom Manage 2012;43:20-8.
30. Koufaki P, Mercer TH, Naish PF. Effects of exercise training on aerobic and functional capacity of end-stage renal disease patients. Clin Physiol Funct Imaging 2002;22:115-24.
31. Ritchie C, Trost SG, Brown W, Armit C. Reliability and validity of physical fitness field tests for adults aged 55 to 70 years. J Sci Med Sport 2005;8:61-70.

32. Ozalevli S, Ozden A, Itil O, Akkoclu A. Comparison of the sit-to-stand test with 6 min walk test in patients with chronic obstructive pulmonary disease. Respir Med 2007;101:286-93.
33. Rocco CC, Sampaio LM, Stirbulov R, Correa JC. Neurophysiological aspects and their relationship to clinical and functional impairment in patients with chronic obstructive pulmonary disease. Clinics 2011;66:125-9.
34. Bohannon RW. Muscle strength: clinical and prognostic value of hand-grip dynamometry. Curr Opin Clin Nutr Metab Care 2015;18:465-70.
35. Mainous 3rd AG, Tanner RJ, Anton SD, Jo A. Grip strength as a marker of hypertension and diabetes in healthy weight adults. Am J Prev Med 2015;49:850-8.
36. Yorke AM, Curtis AB, Shoemaker M, Vangsnes E. Grip strength values stratified by age, gender, and chronic disease status in adults aged 50 years and older. J Geriatr Phys Ther 2015;38:115-21.
37. Amaral CA, Amaral TLM, Monteiro GTR, et al. Hand grip strength: Reference values for adults and elderly people of Rio Branco, Acre, Brazil. PLoS One 2019;14:e0211452.
38. Wong SL. Grip strength reference values for Canadians aged 6 to 79: Canadian Health Measures Survey, 2007 to 2013. Health Rep 2016;27:3.
39. Massy-Westropp NM, Gill TK, Taylor AW, et al. Hand grip strength: age and gender stratified normative data in a population-based study. BMC Res Notes 2011;4:127.
40. Adedoyin RA, Ogundapo FA, Mbada CE, et al. Reference values for handgrip strength among healthy adults in Nigeria. Hong Kong Physiother J 2009;27:21-9.

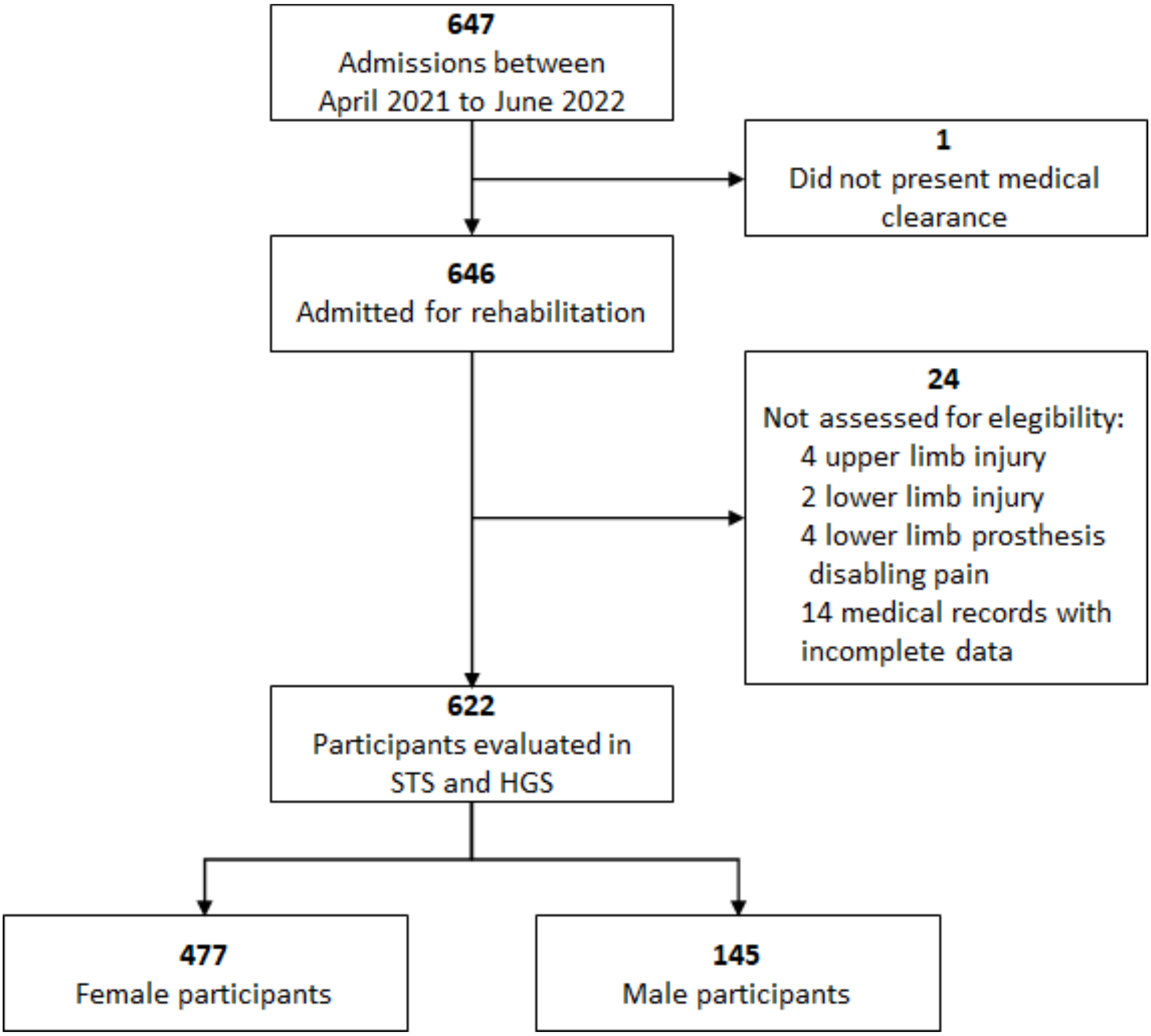

Figure 1. Flow diagram detailing the sample recruitment process. 1min-STD: 1-minute sit-to-stand test; HGS (handgrip strength)

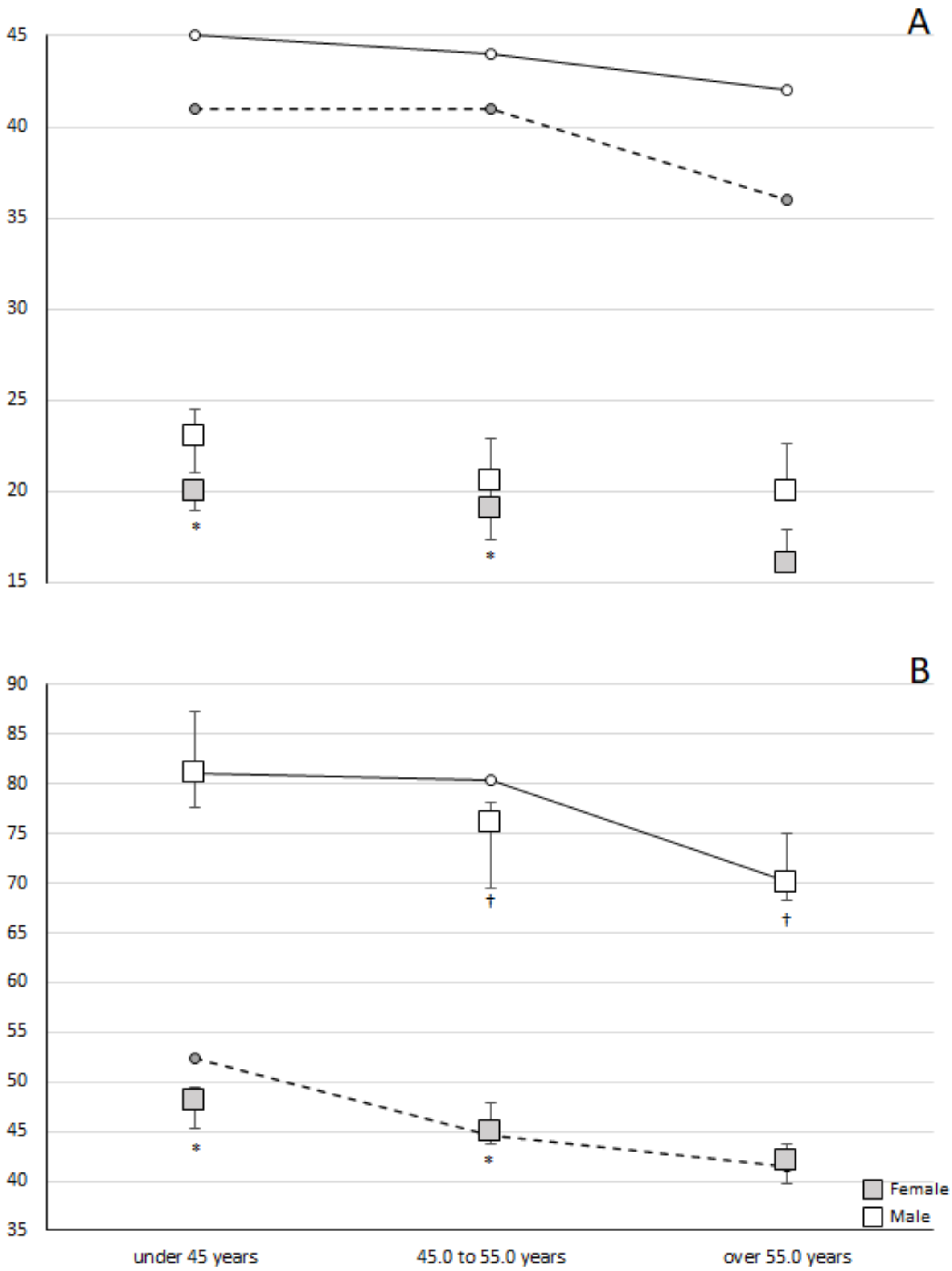

Figure 2. Median comparisons (with 95% confidence intervals) of A) 1-Minute Sit-to-Stand Test (Repetitions) and B) Handgrip Strength (kgf) between age ranges for female and male Groups with Post-COVID-19 Syndrome. Healthy population's median values for the 1-Minute Sit-to-Stand test [32] and Handgrip Strength [47] were represented by continuous lines and white circles for males, and dotted lines and gray circles for females. *Significant difference with "over 54.0 years" group ($p \leq 0.05$); †Significant difference with the "under 45.0 years" group ($p \leq 0.05$)