RESEARCH

COVID-19 in older adult residents in nursing homes: factors associated with mortality and impact on functional capacity

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Abstract

Objective To verify if the functional capacity prior to COVID-19 infection was different between Survivor and Non-survivor older adults. Also, to verify the effect of the isolation period after COVID-19 infection on the functional capacity of the Survivors residing in nursing homes.

Materials and methods Older adults residing in nursing homes were evaluated 30 days before the COVID-19 outbreak at the site for (i) general health characteristics (obtained from medical records); (ii) gait speed, handgrip strength and 30-s sit-to-stand; (iii) sarcopenia and (iv) estimated muscle mass. Comparisons were made between Survivors and Non-survivors of COVID-19. After the isolation, the Survivors performed the assessments again.

Results Twenty-one (81 ± 9.3 years) participants tested positive for COVID-19 and participated in the study, 12 survivors. No difference was observed between Survivors and Non-survivors in any of the outcomes evaluated. However, a moderate effect size was observed for handgrip strength, with lower values for the Non-survivors group (-16%; $d = 0.53$). The isolation period reduced the number of sit-to-stand repetitions with moderate effect size in the Survivors ($p = 0.046$, $g_{av} = 0.66$).

Conclusion Although the null hypothesis analysis did not find significant differences between the groups, the effect size suggests that older adults residing in nursing homes who died from COVID-19 had lower handgrip strength. In the survivors, the isolation period after COVID-19 infection only negatively impacted the sit-to-stand performance.

Keywords COVID-19 · Nursing homes · Mortality · Functional capacity

Introduction

Due to being a little-known disease, COVID-19 spread rapidly and dangerously, becoming a global crisis and triggering varied clinical conditions [1]. A large portion of the population may be exposed to the virus due to its high infection rate [2]. This is particularly important for older adults and those with chronic diseases, who are more susceptible to complications from COVID-19 and have a high fatality rate [3]. Unsurprisingly, nursing homes were particularly threatened by COVID-19, since 22% of deaths prior to the pandemic occurring in these institutions [4]. These places are considered a high-risk environment for infection by COVID-19, with a transmissibility rate greater than 60% [5] and the mortality rate ranging from 30 to 60% of deaths recorded by COVID-19 in the world [6]. This can be largely attributed to the characteristics of its residents, since nursing homes generally house a large number of individuals that are older, are sedentary, feel their health is not good, low cognitive and functional capacity, high levels of dependency and complications of pre-existing diseases, usually aggravated due to institutionalization [7], sarcopenia [8] and the development of frailty [9].

Seeking to minimize the risk of infection among older nursing home residents, when there is suspicion or confirmation of COVID-19, the older person undergoes 14 days of isolation [10]. The isolation affects the lifestyle of these people, contributing to an increase in sedentary behavior, reduced physical activity [11] and reduced food intake [12]. These changes increase the amount of intramuscular non-contractile tissue (reducing the muscle quality) [13] and

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decrease muscle mass, impairing muscle strength [14]. Also, the COVID-19 infection causes an excessive production of pro-inflammatory cytokines in hypercatabolic conditions, which is related to oxidative stress and cause severe damage to muscle tissues. The dynamics of muscle loss in COVID-19 are not yet evident, but some researchers suggest that this result comes from a sum of different factors such as age, metabolic and inflammatory disorders (diabetes, obesity, cardiovascular diseases, cancer, etc.) [15], baseline nutritional status and previous sarcopenia [16, 17].

Thus, the COVID-19 infection, the isolation and the consequent mobility restrictions can compromise strength production and muscle function, factors related to functional disability and increased mortality [18, 19]. However, despite the impact of muscle function on mortality, to date, only one study indicated that patients with sarcopenia prior to COVID-19 infection are more predisposed to mortality when compared to older adults without sarcopenia [20]. However, we are unaware of studies that have investigated whether other functional capacity parameters prior to contamination were different between older adults who survived and those who died from COVID-19. In addition, no studies to date observed whether the period of isolation resulted in substantial reductions in functional capacity in older adults residing in nursing homes who are survivors of COVID-19.

Therefore, the aims of this study were to investigate the impact of social isolation on the functional capacity of institutionalized older adults who survived COVID-19 and to compare the functional capacities prior to the contamination of the survivors and those who did not survive.

Materials and methods

This is an analytical study with a cross-sectional observational design and a quantitative approach. The sample was chosen intentionally based on accessibility convenience and was composed of institutionalized older adults.

Participants

Older adults, residents of nursing homes (two locations) of both sexes and aged over 60 years, were recruited. Participants who tested positive for COVID-19 were included. Bedridden or wheelchair-dependent older adults were excluded. All participants were unvaccinated at the time of infection. Participants did not take part in structured physical activity before or during the isolation period. General health characteristics were obtained from medical records, functional capacity assessment [gait speed, handgrip strength and 30-s sit-to-stand test] and sarcopenia assessment were performed thirty days before the COVID-19 outbreak at the nursing homes. The study was approved by the university's Research

Ethics Committee (protocol number 4.699.191) and all participants signed an informed consent form before the study.

Experimental design

All initial sample characteristics were obtained by accessing the nursing homes' medical records. Age, sex, body mass, height, body mass index (BMI) and cognitive status assessed by the Mini Mental State Examination (MMSE) [21], using the version validated for Brazilian population [22] were used to characterize the sample.

The presence of multicomorbidity was determined as proposed by a previous study [15] and the presence of sarcopenia was defined according to the recommendations of the European Working Group on Sarcopenia in Older People (EWGSOP2) [8]. Functional capacity data were measured 1 month before the COVID-19 outbreak at the nursing home (December 2020). Older adults who tested positive for COVID-19 underwent a 14-day isolation period. One participant had a longer isolation period due to being hospitalized. One week after the isolation period, the surviving older adults underwent the same evaluation procedures performed previously (Fig. 1). The values obtained prior to infection were used to compare those who died (Non-survivors) with those who survived (Survivors).

Assessments and instrumentation

Due to the particularities of the study population, such as low visual acuity, illiteracy and motor coordination alterations, the questionnaires were applied in the form of an interview, to minimize possible errors in the interpretation of the questions. The following protocols were used according to previous studies.

Multicomorbidity index

This instrument was developed to specifically analyze the association between multicomorbidity and risk of severe COVID-19 infection. The presence of following conditions was obtained from the nursing home medical records: angina, asthma, atrial fibrillation, cancer, chronic kidney disease, chronic obstructive pulmonary disease, diabetes mellitus, heart failure, hypertension, myocardial infarction, peripheral vascular disease, and stroke. Participants who had two or more of the conditions were classified as positive multicomorbidity and those who presented zero or only one were classified as negative multicomorbidity [15].

Sarcopenia

Sarcopenia was defined according to the criteria proposed by the EWGSOP2 [8]. Severe sarcopenia was present when
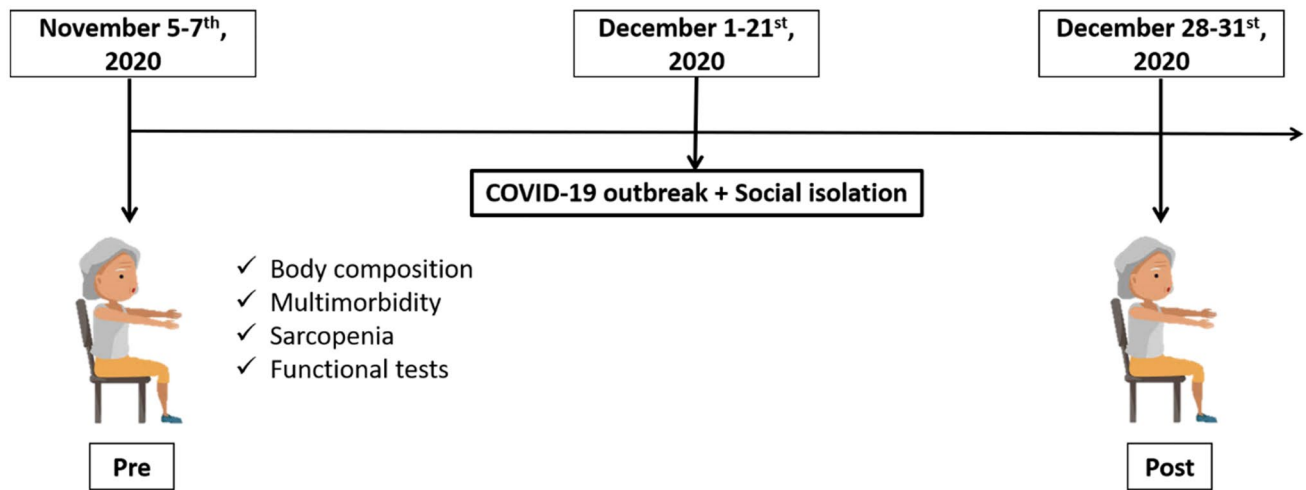
Fig. 1 Experimental design

there was a reduction in strength, muscle mass and physical performance; sarcopenia with the presence of low strength and muscle mass and absence of sarcopenia when only low muscle strength was identified, with no change in the other items evaluated. For muscle strength and physical performance assessments, three trials were performed and the best of the three was used. Muscle strength was determined by the handgrip test, obtained using a digital dynamometer (model EH101, Camry Scale, CA, USA), following previous recommendations [23]. Physical performance was measured with the 4-m gait speed test, measuring the time for completion of the test and calculating the speed in meters per second.

Muscle mass was estimated using the following formula de Lee [24]:

$$\text{Muscle mass (kg)} = \text{height (m)} \times (0.244 \times \text{body mass(kg)})$$
$$+ (7.8 \times \text{height (m)}) + (6.6 \times \text{sex})$$
$$- (0.098 \times \text{age (years)}) + (\text{ethnicity} - 3.3),$$

where men = 1 and women = 2 for sex and Asian = 1.2, afro descendent = 1.4 and Caucasians = 0 for ethnicity. This equation was validated [20], showing a high correlation with DXA (dual energy X-ray) to estimate the amount of lean mass in men ($r = 0.90$; $p < 0.001$) and in women ($r = 0.86$; $p < 0.001$). Specificity was 86% and sensitivity was 89% [25].

The cutoff points adopted were those recommended by the EWGSOP2, in which handgrip strength was considered "low" when values were below 27 kg for men and below 16 kg for women. Gait speed was considered "low" when it was lower than 0.8 m/s for both sexes. For muscle mass, the muscle mass/height index^2 was used, with values below 5.5 kg/m^2 for women and 7 kg/m^2 for men being considered

low. This is the same cutoff values determined for evaluations performed by DXA [6].

Functional capacity

In addition to the gait speed and handgrip strength tests (previously described in the sarcopenia session), the 30-s sit-to-stand test was performed in a chair with a height of 43 cm and the back supported by a wall. The assessment started with the participant sitting with the spine erect and feet flat on the floor. To minimize the risk of falling, the researcher gave both hands to all the participants, since some were not confident, they could perform the task alone. At the signal, the participant had to stand up completely and then return to the initial position, completely seated. Participants were encouraged to sit and stand as many times as possible within 30 s, without pulling on the researcher's hand. The result recorded was the number of times the participant correctly performed the movements within 30 s [26]. Three attempts were performed with an interval of three minutes between each attempt, with the best attempt being recorded.

Statistical analysis

Descriptive statistics were used to characterize the sample, with calculation of the mean and standard deviation for all quantitative variables. Nominal variables (gender, multicomorbidity and sarcopenia) were presented as absolute (N) and relative (%) frequencies. To analyze the proportion of sarcopenia and multicomorbidity in the groups (Non-survivors and Survivors) a Pearson chi-square (X^2) test was performed (minimum expected count: > 5). When the expected count was lower than necessary, Fisher's exact test was performed. To compare the variables of functional capacity

(gait speed, handgrip strength and 30-s sit-to-stand), body mass index and muscle mass between the groups, the *t* test for independent samples (or Mann–Whitney *U* for non-parametric data) was used, considering the degree of homogeneity of variances given by Levene's test. The effect size between groups was calculated for the functional capacity outcomes using Cohen's d and classified as trivial (<0.2), small (0.2–0.5), moderate (0.5–0.8), large (0.8–1.3) and very large (>1.3) [27].

In the pre- and post-isolation comparisons of the Survivors group, the variables were compared using paired *t* tests (or Wilcoxon tests in non-parametric data). Pearson's Chi-square test (X^2) compared the presence of sarcopenia between pre- and post-moments (minimum expected count: >5; Fisher's exact test when the expected count was lower than necessary). Hedges "g_{av}" (calculated from Cohen's "d_{av}") was used to calculate the effect size of the functional capacity tests between moments, with values of 0.2, 0.5 and 0.8 classified as small, medium, and large, respectively [28]. In all tests, a significance level of 5% ($p \leq 0.05$) was considered and all procedures were performed in SPSS 22.0 software.

Results

From the older adults, resident at the nursing homes, 61 were assessed for eligibility for the study. A total of 40 people were excluded because they did not meet the inclusion criteria, being bedridden ($n = 22$), wheelchair-dependency ($n = 15$) and not having been contaminated by COVID-19 ($n = 3$). Thus, a total of 21 participants took part in the study

(Fig. 2). Sample characteristics are presented in Tables 1 and 2.

The first cases of COVID-19 were confirmed in early December 2020, with the first death recorded on December 7th. After contamination by COVID-19, 57% ($n = 12$) survived and 43% ($n = 9$) did not. From the Survivor groups, only one person was referred to the hospital, remaining hospitalized for 17 days. The remaining participants were in isolation at the nursing home for an average of 14.3 days. Evaluations were carried out 1 week after the participants were released from isolation. The mean time between pre and post assessment was ~50 days.

The comparison between the Survivors and Non-survivors groups did not show significant differences in anthropometrics and cognitive characteristics (Table 3). There was also no association between the frequency of the presence of multicomorbidity and sarcopenia (Table 4).

Table 1 Sample characteristics

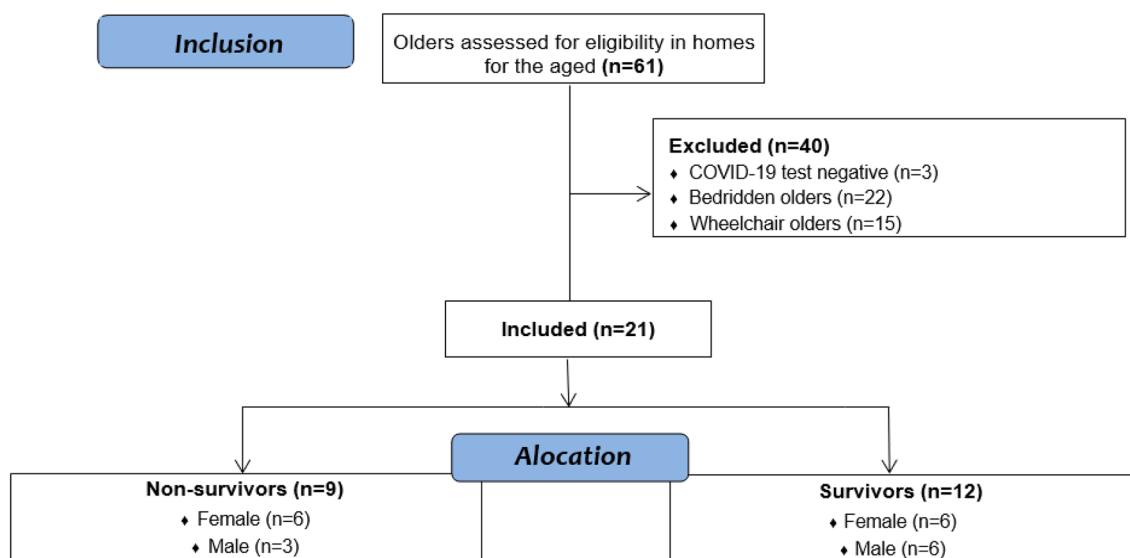| $n = 21$	Mean	±SD
Age (years)	81.1	9.3
Height (m)	1.57	0.12
Muscle mass (kg/m^2)	8.3	2.1
Body mass (kg)	67.9	16.1
Body mass index (kg/m^2)	27.5	5.0
Mini Mental State Examination (pts)	19.4	5.9
Gait speed (m/s)	0.61	0.23
Handgrip strength (kg)	19.1	7.9
30-s sit-to-stand test (rep)	11.9	3.5

Fig. 2 Sample inclusion and allocation flowchart

Table 2 Absolute and relative frequency of the different sex, sarcopenia and multicomorbidity categories

	$n = 21$	
	Absolute (n)	Relative (%)
Sex		
Female	12	57
Male	9	43
Sarcopenia		
Severe sarcopenia	3	14
Sarcopenia	0	0
Absent sarcopenia	18	88
Multicomorbidity		
Positive	11	52
Negative	10	48

Regarding the functional capacity parameters, we did not observe significant differences between the groups for gait speed (-8%) $[t(19) = -0.581, p = 0.622, d = 0.39$ (small)] and for the sit-to-stand test (-9%) $[t(11.44) = -0.527, p = 0.608, d = 0.22$ (small)]. However, although we did not observe statistically significant differences for handgrip strength (-16%), a moderate effect size was observed with lower values for the Non-survivors group $[t(19) = -0.916, p = 0.371, d = 0.53$ (moderate)] (Fig. 3).

After the isolation period, we did not observe a significant difference in in anthropometrics and cognitive characteristics (Table 5). Regarding sarcopenia, we found no difference in the frequency between pre- and post-isolation moments $(p = 1.00)$. As for the functional capacity variables, we did not observe a significant reduction in gait speed $[t(11) = 1.23, p = 0.244, g_{av} = 0.18$ (small)] and in handgrip strength $[t(11) = 0.81, p = 0.438, g_{av} = 0.14$ (small)]. However, we observed a significant reduction (14%) in the sit-to-stand test between the pre- and post-isolation periods $[t(11) = 2.24, p = 0.046), g_{av} = 0.66$, moderate] (Fig. 4).

Table 4 Frequency of the presence of sarcopenia and multicomorbidity between the groups

Classification	Survivors n (%)	Non-survivors n (%)	p
Sarcopenia			
Absent sarcopenia	12 (100)	6 (67)	0.063
Severe sarcopenia	0 (0)	3 (33)	
Multicomorbidity			
Positive	5 (42)	6 (67)	0.387
Negative	7 (58)	3 (33)	

Discussion

Our study sought to compare the functional characteristics of older adults who survived and those who did not survive the COVID-19 infection and to investigate the impact of social isolation on the functional capacity of the Survivors. We observed that (i) there were no differences between Survivors and Non-survivors in relation to age, BMI and estimated muscle mass; (ii) there was no association between multicomorbidity or sarcopenia and the disease outcome; (iii) there were no statistically significant differences in functional capacity parameters between Survivors and Non-survivors. However, a moderate effect size was observed for handgrip strength, with smaller values for the Non-survivor group. Regarding the Survivors, the period of social isolation did not significantly alter gait speed, handgrip strength, sarcopenia profile, anthropometric measurements and cognitive data. However, there was a significant reduction in the number of 30-s sit-to-stand test repetitions with a moderate effect size.

Older adults who reside in institutions such as nursing homes are more vulnerable and have high mortality rates from COVID-19 [29]. In general, they show greater deterioration in their nutritional and functional status, which can have negative consequences for their health [30]. In particular, the presence of sarcopenia is widely associated with a higher risk of mortality in older adults from various causes, regardless of age and other associated health and functional
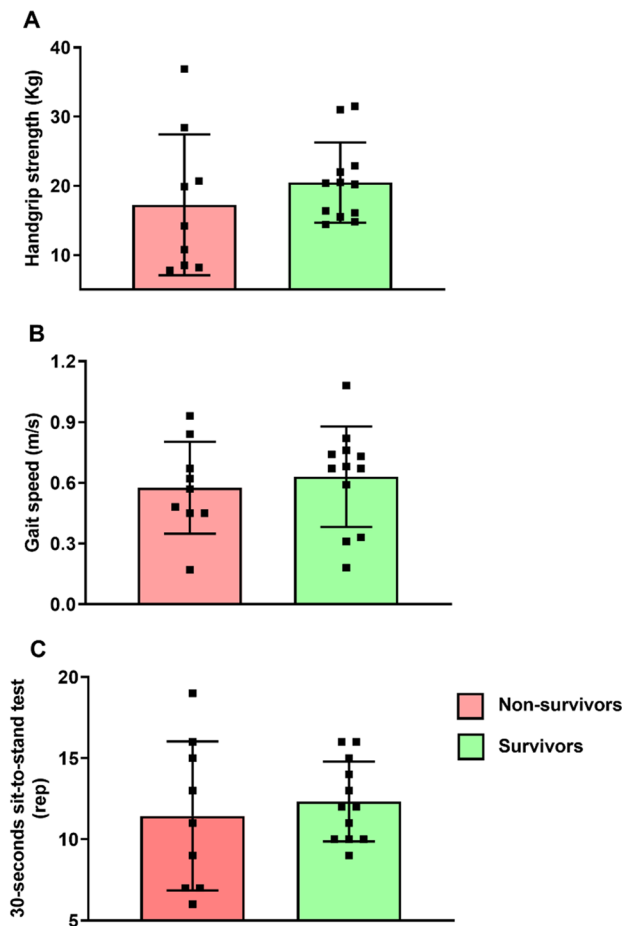
Table 3 Sample characteristics divided by group

	Survivors ($n = 12$) Mean ($\pm$ SD)	Non-survivors ($n = 9$) Mean ($\pm$ SD)	p
Age (years)	79.3 ($\pm$ 10.2)	83.4 ($\pm$ 7.9)	0.331
Height (m)	1.56 ($\pm$ 0.11)	1.57 ($\pm$ 0.12)	0.902
Muscle mass (kg/m^2)	8.8 ($\pm$ 1.8)	7.8 ($\pm$ 2.3)	0.294
Body mass (kg)	69.4 ($\pm$ 14.6)	65.9 ($\pm$ 18.7)	0.631
Body mass index (kg/m^2)	28.4 ($\pm$ 5.0)	26.3 ($\pm$ 5.2)	0.377
Mini Mental State Examination (pts)	20.1 ($\pm$ 6.1)	18.4 ($\pm$ 5.9)	0.543

Fig. 3 Comparison between groups for the functional capacity variables: handgrip strength (**A**), gait speed (**B**) and 30-s sit-to-stand (**C**)

conditions [31, 32]. Patients with sarcopenia before COVID-19 infection (living in their homes) tend to be more predisposed to mortality when compared to older adults without sarcopenia [20, 33]. Although the presence of sarcopenia was not significantly different between the Survivor and Non-survivor groups, the p value was close to the significance threshold ($p = 0.063$) and all the participants that were considered to have severe sarcopenia did not survive and all participants in the Survivor group had absent sarcopenia. In our study, only 14% ($n = 3$) of the participants were classified as sarcopenic, which is different from a previous study

that reported that residents of nursing homes have a high prevalence of sarcopenia [34].

We are unaware of studies that have investigated the relationship between mortality due to COVID-19 and functional capacity, especially in residents of nursing homes. A previous study that assessed functional capacity at hospital admission (with nursing home residents accounting for a large part of the sample) based on the Katz and Lawton questionnaires for basic and instrumental activities observed greater functional impairment in older adults who did not survive COVID-19 [35]. Our study evaluated functional capacity through performance in physical tests (sit-to-stand, gait speed and handgrip strength) and did not observe any difference between Survivors and those who did not in the null hypothesis analysis. However, a moderate effect size was found for lower handgrip strength values in the group that died (− 16%). These parameters are considered important predictors of mortality from different causes [36]. Handgrip strength has been identified as an excellent marker of general muscle strength, and lower values seem to be related to worse conditions in several health outcomes [37]. In fact, a previous study suggested the use of handgrip strength as a prognostic tool for morbidity and mortality in older adults after COVID-19 infection [38], which was partially corroborated by our results. Regarding the role of sarcopenia and muscle strength on mortality, the possible explanation is that a maintenance of muscle mass serves as a metabolic reservoir that is needed to effectively withstand disease [39], while the muscle strength, is hypothesized a relationship with anabolic hormones (e.g. testosterone and insulin-like growth factor-I) which acts offering a protection against metabolic diseases and are reduced during aging [40].

Our study also sought to verify the effects of the isolation period after infection by COVID-19. Social isolation due to the COVID-19 pandemic contributes to a sedentary lifestyle, modifying body composition by increasing non-contractile tissue [11], which impairs muscle quality and or quantity [41]. Generally, studies looking at body composition related to COVID-19 used bioimpedance-based measurements and reported decreased muscle mass and strength [42, 43]. Due to limitations in the instruments available, we were only able to evaluate body composition using the body mass index [44] and the estimated muscle mass [24], which are less precise but have been validated

Table 5 Sample characteristics of the Survivor group pre and post the isolation period due to COVID-19 infection

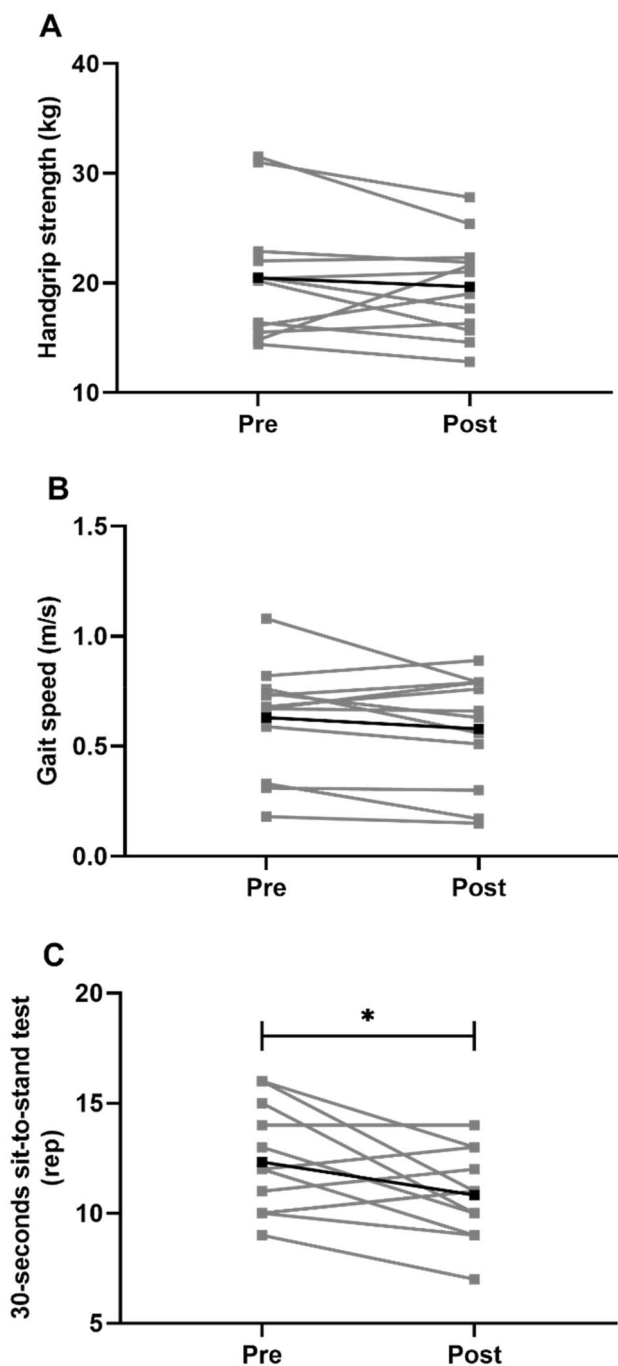| $n = 12$	Pre		Post		p
	Mean	($\pm$SD)	Mean	($\pm$SD)	
Muscle mass (kg/m^2)	8.8	($\pm$1.8)	8.9	($\pm$1.7)	0.430
Body mass (kg)	69.4	($\pm$14.6)	71.2	($\pm$13.8)	0.365
Body mass index (kg/m^2)	28.4	($\pm$5.0)	29.0	($\pm$4.1)	0.379
Mini Mental State Examination (pts)	20.1	($\pm$6.1)	18.7	($\pm$6.7)	0.075

Fig. 4 Comparison between the pre- and post-isolation moments in the survivor group for the functional capacity variables: handgrip strength (**A**), gait speed (**B**) and 30-s sit-to-stand (**C**)

and are often used [25, 45]. However, using this method, we did not observe changes in body mass index and muscle mass after the period of social isolation. A possible explanation is related to the increase in the amount of intramuscular non-contractile tissue and decrease in muscle mass, which did not change the total body mass. As body mass index and muscle mass was estimated using body mass and height, an increase in non-contractile tissue was not able to be measured after the isolation due to COVID-19 infection, justifying our results. The mechanisms are related to physical inactivity during isolation plus COVID-19 infection, that causes a chronic low-grade inflammation that acts on the brain, neuromuscular junctions and musculoskeletal system, causing atrophy of muscle fibers [19].

The isolation period after COVID-19 infection resulted in a significant reduction only in the sit-to-stand test, with a moderate effect size. It has recently been observed that sit-to-stand has a weak correlation with muscle strength, but a strong correlation with cardiorespiratory capacity assessed by a 6-min walk test [46]. Since infection by COVID-19 is associated with decreased cardiorespiratory capacity [16], it is possible that the reduction in sit-to-stand performance was related to the decrease in cardiorespiratory capacity resulting from COVID-19. The lack of significant difference for handgrip strength and gait speed likely also affected the sarcopenia profile of the participants, since they are both used for its evaluation [8]. In our study, we used handgrip strength to define the risk of sarcopenia, the amount of lean mass to confirm the condition, and gait speed to determine the severity of sarcopenia [8]. Thus, the non-change in the sarcopenia profile after the isolation period may be due to the results of the handgrip strength and gait speed tests.

This study was the first to assess whether performance on functional capacity tests was capable of differentiating institutionalized elderly people who survived and those who died from COVID-19, as well as the impact of social isolation on these parameters. However, it has some important limitations: (i) we did not previously define a cutoff point for the cognition of the elderly included in the study, which may impact the ability to understand instructions and affect the performance of tasks. (ii) The sample was chosen based on accessibility and, consequently, we had a small number of people evaluated, limiting the extrapolation of the results to the large population of older adults who reside in nursing homes. However, the moderate effect sizes found for handgrip strength and sit-to-stand test suggests that these variables could be different between groups and pre- and post-isolation moments, respectively. (iii) The determination of sarcopenia presence and severity is dependent on the functional tests used [8]. Thus, if other functional tests that evaluate similar capacities as the sit-to-stand test were also included in the sarcopenia profile measurement (e.g., timed up and go), the results could have been different. However, we used a method that was previously used by similar studies [47].

Conclusion

Our results suggest that older adults resident in nursing homes who did not survive COVID-19 had lower handgrip strength values compared to those who survived. In the Survivors, the isolation period only negatively impacted the sit-to-stand performance. These results reinforce the needed of regular physical activity programs for older adults resident in nursing homes, which will acts protecting against sarcopenia, loss of muscle strength and, consequently, mortality.

Availability of data and material Not applicable.

Code availability Not applicable.

Declarations

Conflict of interest The authors declared no conflict of interest.

Ethics approval The study was approved by the University's Research and Ethics Committee (n: 4.699.191). This study followed all ethical principles contained in the Helsinki Declaration.

Consent to participate Before starting, all participants were informed of the aims and procedures of the study and signed an informed consent form.

Consent for publication Not applicable.

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