Research Article

Hand-Grip Strength, Body Composition and Functional Capacity in Adults During Early Recovery From COVID-19:A Comparative Cross-Sectional Study

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ABSTRACT

Objective: To compare hand-grip strength, body composition and functional capacity between adults in early recovery from coronavirus disease 2019 and healthy controls, and to examine how grip strength relates to body composition and walking capacity in each group.

Methods: Comparative cross-sectional study with 20 adults recovering from coronavirus disease 2019 (recovered group), assessed between the 17th and 30th day after symptom onset or first positive reverse-transcription polymerase chain reaction test, and 20 age- and sex-matched healthy controls. Grip strength was measured with a hand-held dynamometer, body composition with bioelectrical impedance analysis, and functional capacity with the six-minute walk test. Groups were compared with the independent-samples t-test, and associations were examined with Pearson correlation (significance at $p \leq 0.05$).

Results: Each group had 15 men and 5 women, mean age 41 ± 13.8 years. Grip strength did not differ between groups (25.7 ± 7.0 versus 24.9 ± 10.1 kg; $p = 0.779$). The recovered group had higher body mass index, body fat percentage, visceral fat, skeletal muscle mass and six-minute walk distance (all $p < 0.05$). In the recovered group, grip strength correlated inversely with body fat percentage ($r = -0.588$) and skeletal muscle mass ($r = -0.574$); in controls, it correlated positively with walk distance ($r = 0.482$).

Conclusion: In early recovery from coronavirus disease 2019, grip strength was similar to that of healthy controls despite greater adiposity. The inverse association between body fat and grip strength suggests that muscle quality, not only muscle quantity, deserves attention during post-infection rehabilitation.

Keywords: COVID-19; Hand Strength; Body Composition; Muscle Strength Dynamometer; Electric Impedance; Walk Test.

INTRODUCTION

Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first reported in Wuhan, China, in late 2019 and was declared a pandemic by the World Health Organization in March 2020. It spreads mainly through respiratory droplets and direct contact, and commonly presents with fever, cough, headache, myalgia and fatigue. Most patients recover, but older adults and people with diabetes mellitus, cardiovascular disease or obesity are at greater risk of severe illness and intensive care.[1] Although COVID-19 is primarily a respiratory illness, it affects several other organ systems, including skeletal muscle.[1] Several mechanisms contribute to muscle loss. Pro-inflammatory cytokines such as interleukin-6 and tumour necrosis factor-α promote muscle protein breakdown and suppress protein synthesis. Hypoxaemia, reduced food intake, corticosteroid treatment and bed rest during hospitalisation add to this catabolic state, and together they can produce acute sarcopenia within weeks.[1,2] A meta-analysis of 21 studies with 5,407 patients estimated the pooled prevalence of sarcopenia in COVID-19 at 48%.[3]

These changes can persist well beyond the acute illness. After the 2003 SARS outbreak, survivors of moderate to severe disease showed a 32% reduction in grip strength and a 13% reduction in six-minute walk distance two to three months after discharge.[1] After COVID-19, fatigue or muscle weakness was the most frequent complaint six months after discharge in a large hospital cohort,[4] and patients recovering from COVID-19 pneumonia show reduced peripheral muscle strength and physical performance.[5] A recent meta-analysis of functional recovery reported pooled grip strength of about 28.5 kg and six-minute walk distance of about 84% of predicted at three to five months, with walking capacity still below population norms after one year.[6]

Hand-grip strength is a simple, inexpensive and reliable marker of overall muscle strength. Low grip strength predicts all-cause and cardiovascular mortality and disability,[7,8] and it is the primary criterion for probable sarcopenia in the current European consensus.[9] Grip strength alone, however, cannot show whether weakness reflects reduced muscle mass, excess fat or poor muscle quality. Obesity is common among patients with COVID-19, and the combination of low muscle function with high adiposity, termed sarcopenic obesity, carries a worse

prognosis than either condition alone.[10] Sarcopenia has been found in about one in five patients recovering from COVID-19, more often after longer hospital stays,[11] and body mass index alone can hide these changes. Combining grip strength with body composition analysis and a functional walking test therefore gives a more complete picture of musculoskeletal recovery.

Most published studies have assessed patients three months or more after discharge, often without a matched healthy control group, and few have combined strength, body composition and walking capacity in the first month after infection.[6] Data from South Asian populations are also limited. This early period matters clinically, because it is when patients are discharged to outpatient follow-up and when rehabilitation can most easily be started.

This study therefore aimed to compare hand-grip strength, body composition and functional capacity between adults in early recovery from COVID-19 and age- and sex-matched healthy controls, and to examine how grip strength relates to body composition and walking capacity in each group. We hypothesised that grip strength would be lower in the post-COVID-19 group and would be positively associated with skeletal muscle mass and six-minute walk distance.

METHODS

Study design and setting

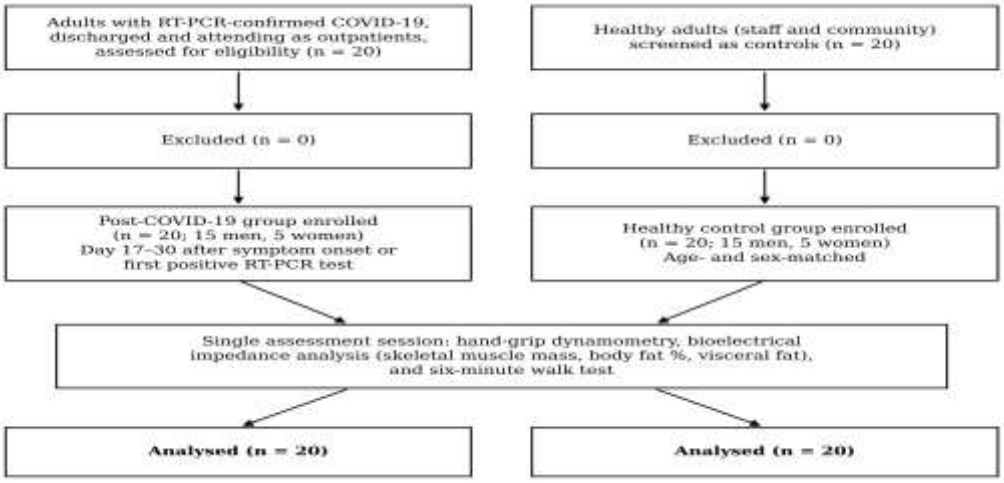
This was a comparative cross-sectional (observational analytic) study, reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[12] Data were collected at Father Muller College of Physiotherapy, Mangaluru, India, between August 2020 and March 2021, and all participants gave written informed consent before assessment. Approval from the Father Muller Institutional Ethics Committee, Mangaluru, was obtained retrospectively, after data collection had been completed (protocol no. 946/2021; reference FMIEC/CCM/967/2021; dated 15 October 2021).

Participants

The post-COVID-19 group included adults with COVID-19 confirmed by reverse-transcription polymerase chain reaction (RT-PCR), who had been discharged from hospital, were symptom-free at the time of assessment, and attended as outpatients. They were assessed between the 17th and 30th day after the first day of symptoms, or after the first positive RT-PCR test in patients who had been asymptomatic. This window corresponds to the early post-acute phase of the illness.

The control group included healthy adults younger than 85 years, recruited from institutional staff and the local community, with no self-reported history of COVID-19. Controls were matched to the post-COVID-19 group for age and sex. In both groups, people were excluded if they had a neurological disorder, a musculoskeletal disorder, a recent fracture of the upper limb, or were unable to understand or comply with the assessment procedures. All 20 people assessed for eligibility in each group met the criteria and were enrolled; none were excluded (Figure 1).

Figure 1. Flow diagram of participant recruitment and assessment



No participants were excluded in either group.

Before assessment, participants in the post-COVID-19 group had received home-based telerehabilitation through pre-recorded videos based on the World Health Organization leaflet on self-management after COVID-19-related illness.[13] The programme covered positions to ease breathlessness, breathing control exercises, thoracic mobility exercises, incentive spirometry, warm-up, graded aerobic exercise, strength training and cool-down.

Sample size

Sample size was calculated with the formula for comparing two independent means,[14] $n = 2(Z\alpha + Z\beta)^2\sigma^2 / (\bar{x}_1 - \bar{x}_2)^2$, with $Z\alpha = 1.96$ (two-sided $\alpha = 0.05$) and $Z\beta = 1.281$ (90% power). The calculation assumed a large standardised difference in grip strength between groups ($(\bar{x}_1 - \bar{x}_2)/\sigma \approx 1.1$), which gave a minimum required sample of 18 per group. Twenty participants were enrolled in each group.

Outcome measures

Hand-grip strength (primary outcome) was measured with a hand-held dynamometer and recorded in kilograms. Hand dynamometry is a reliable and widely used measure of overall muscle strength,[15] and grip strength is the recommended first test for sarcopenia.[9]

Body composition was assessed by bioelectrical impedance analysis,[16] which estimates body water from the resistance of body tissues to a small alternating current and derives skeletal muscle mass (kg), body fat percentage and visceral fat level. Body weight was recorded, height was measured, and body mass index was calculated as weight (kg) divided by height squared (m^2).

Functional capacity was assessed with the six-minute walk test.[17] The total distance covered was recorded in metres. The six-minute walk test is a valid and reliable measure of submaximal functional capacity[17] and has been widely used to monitor recovery after COVID-19.[6]

Statistical analysis

Data were analysed with SPSS software (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation and categorical variables as frequency (percentage). Because the two groups were independent, between-group differences were tested with the independent-samples t-test. Mean differences are presented with 95% confidence intervals, and Cohen's d is reported as the effect size (0.2 small, 0.5 medium, 0.8 large). Associations of grip strength with anthropometric, body composition and functional variables were examined separately in each group with Pearson's correlation coefficient, interpreted as weak ($|r| < 0.3$), moderate (0.3–0.5) or strong (> 0.5). Significance was set at $p \leq 0.05$.

A sensitivity power analysis was also performed. With 20 participants per group, two-sided $\alpha = 0.05$ and 80% power, the study could detect a between-group difference in grip strength of Cohen's $d \geq 0.91$, equivalent to about 7.9 kg given the pooled standard deviation of 8.7 kg, and within-group correlations of $|r| \geq 0.59$.

Variable	Post-COVID-19 (n = 20)	Healthy controls (n = 20)	Mean difference (95% CI)	p value	Cohen's d
Demographic and anthropometric characteristics					
Age (years)	41.0 ± 13.8	41.0 ± 13.8	0.0	1.000	0.00
Sex, men / women, n (%)	15 (75) / 5 (25)	15 (75) / 5 (25)	—	1.000†	—
Height (cm)	169.25 ± 10.10	160.76 ± 6.53	8.50 (3.05 to 13.94)	0.003	1.00
Weight (kg)	79.23 ± 11.73	62.35 ± 8.68	16.89 (10.28 to 23.49)	< 0.001	1.64
Body mass index (kg/m²)	27.71 ± 3.75	24.12 ± 3.27	3.58 (1.33 to 5.84)	0.003	1.02
Outcome measures					
Hand-grip strength (kg)	25.65 ± 7.03	24.88 ± 10.06	0.78 (−4.78 to 6.33)	0.779	0.09
Six-minute walk distance (m)	483.50 ± 113.30	369.15 ± 85.35	114.35 (50.14 to 178.56)	0.001	1.14

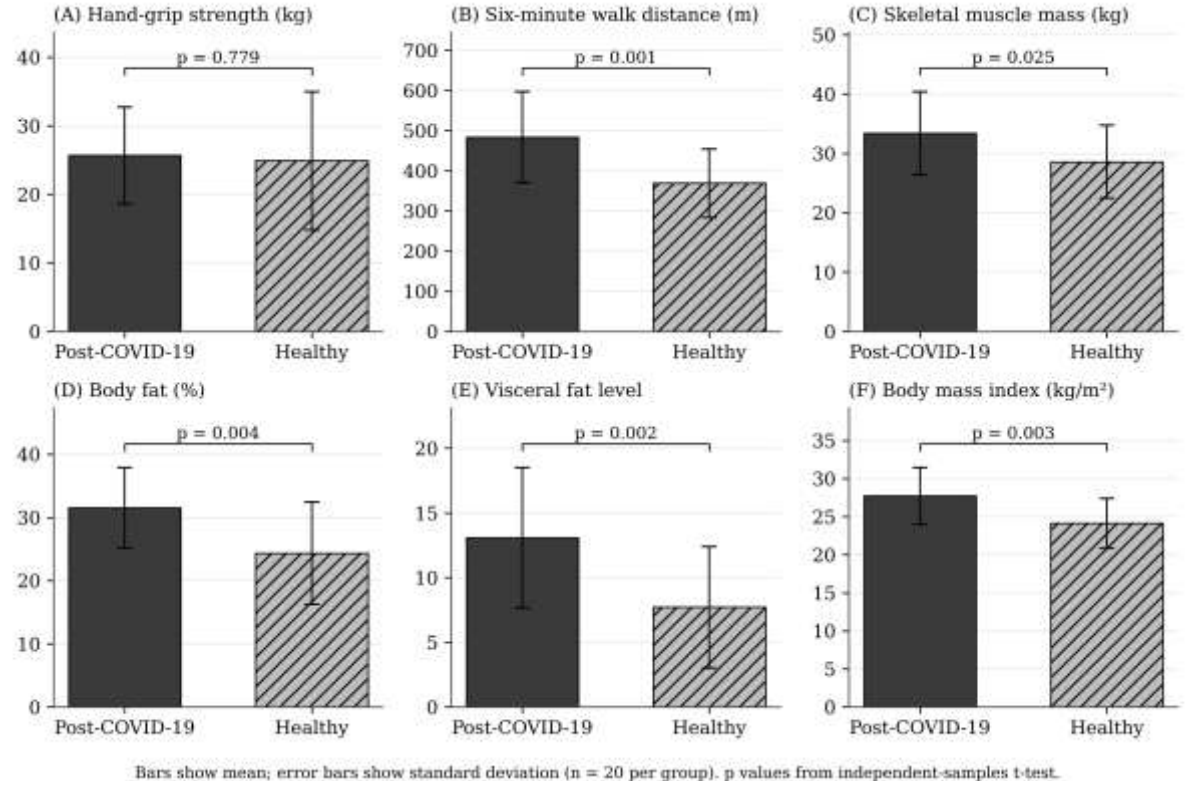
Variable	Post-COVID-19 (n = 20)	Healthy controls (n = 20)	Mean difference (95% CI)	p value	Cohen's d
Skeletal muscle mass (kg)	33.41 ± 6.97	28.57 ± 6.14	4.84 (0.64 to 9.05)	0.025	0.74
Body fat (%)	31.50 ± 6.40	24.32 ± 8.11	7.18 (2.50 to 11.86)	0.004	0.98
Visceral fat level	13.08 ± 5.44	7.71 ± 4.69	5.37 (2.12 to 8.62)	0.002	1.06

RESULTS

Forty participants were analysed, 20 per group, with no missing data (Figure 1). Each group had 15 men (75%) and 5 women (25%), and mean age was identical in both groups (41 ± 13.8 years; p = 1.000), consistent with matching. Despite this, the groups differed in body size: the post-COVID-19 group was taller (mean difference 8.5 cm), heavier (16.9 kg) and had a higher body mass index (3.6 kg/m²) than the control group (Table 1)

Values are mean ± standard deviation unless stated otherwise. p values from independent-samples t-test; † identical distribution by design (matched groups). Mean differences and effect sizes were calculated from unrounded values. CI, confidence interval. Effect size (Cohen's d): 0.2 small, 0.5 medium, 0.8 large.
Hand-grip strength did not differ between the post-COVID-19 and control groups (25.65 ± 7.03 versus 24.88 ± 10.06 kg; mean difference 0.78 kg, 95% CI −4.78 to 6.33; p = 0.779; d = 0.09). The lower limit of the confidence interval excludes a deficit greater than 4.8 kg in the post-COVID-19 group. The post-COVID-19 group had higher body fat percentage (31.50 ± 6.40 versus 24.32 ± 8.11%; p = 0.004; d = 0.98), visceral fat level (13.08 ± 5.44 versus 7.71 ± 4.69; p = 0.002; d = 1.06) and skeletal muscle mass (33.41 ± 6.97 versus 28.57 ± 6.14 kg; p = 0.025; d = 0.74). It also walked a longer six-minute walk distance (483.50 ± 113.30 versus 369.15 ± 85.35 m; p = 0.001; d = 1.14) (Table 1, Figure 2).

Figure 2. Comparison of hand-grip strength (A), six-minute walk distance (B), skeletal muscle mass (C), body fat percentage (D), visceral fat level (E) and body mass index (F) between the post-COVID-19 and healthy control groups



Bars show means and error bars standard deviations (n = 20 per group); p values from independent-samples t-test.

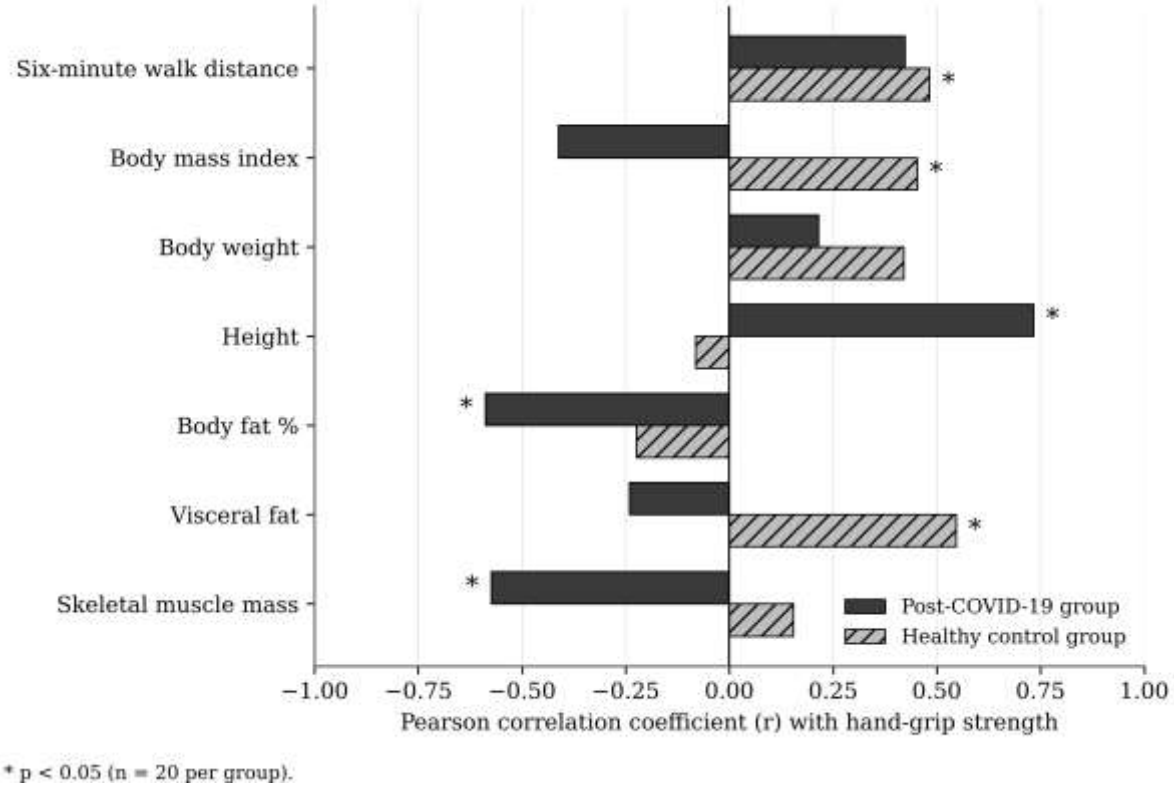
Correlations between grip strength and the other measures differed between groups (Table 2, Figure 3). In the post-COVID-19 group, grip strength correlated strongly and positively with height (r = 0.733; p < 0.001) and strongly and inversely with body fat percentage (r = −0.588; p = 0.006) and skeletal muscle mass (r = −0.574; p = 0.008). Its moderate positive association with six-minute walk distance (r = 0.423; p = 0.063) and moderate inverse association with body mass index (r = −0.412; p = 0.071) did not reach significance. In the control group, grip strength correlated strongly with visceral fat (r = 0.546; p = 0.013) and moderately with six-minute walk distance (r = 0.482; p = 0.031) and body mass index (r = 0.452; p = 0.046).

Table 2. Pearson correlation of hand-grip strength with body composition and functional capacity in each group

Variable correlated with hand-grip strength	Post-COVID-19 r	p value	Healthy controls r	p value
Six-minute walk distance	0.423	0.063	0.482	0.031*
Body mass index	−0.412	0.071	0.452	0.046*
Body weight	0.214	0.365	0.420	0.065
Height	0.733	< 0.001*	−0.081	0.733
Body fat percentage	−0.588	0.006*	−0.224	0.342
Visceral fat level	−0.241	0.306	0.546	0.013*
Skeletal muscle mass	−0.574	0.008*	0.154	0.517

r, Pearson correlation coefficient; n = 20 per group. * p < 0.05.

Figure 3. Correlation of hand-grip strength with anthropometric, body composition and functional variables in the post-COVID-19 and healthy control groups



Bars show Pearson correlation coefficients; * p < 0.05 (n = 20 per group).

DISCUSSION

This study found that adults assessed 17 to 30 days after the onset of COVID-19 had grip strength similar to that of age- and sex-matched healthy controls, but greater body fat and visceral fat. Within the post-COVID-19 group, higher body fat was associated with lower grip strength. Contrary to our hypothesis, grip strength was not lower after COVID-19 and was not positively associated with skeletal muscle mass.

The absence of a grip strength deficit differs from studies reporting reduced strength after COVID-19.[1,5] Several features of our sample may explain this. First, although our participants had been discharged from hospital, disease severity, length of stay and need for intensive care were not recorded. Earlier reports focused on patients recovering from pneumonia or critical illness,[4,5] and acute sarcopenia is most pronounced after prolonged immobilisation;[2] if our sample included mainly milder cases, smaller deficits would be expected. Second, all post-COVID-19 participants had received structured home-based telerehabilitation based on the World Health Organization self-management guidance before assessment.[13] A randomised trial of a six-week home-based telerehabilitation programme after discharge improved walking distance, lower limb muscle strength and physical quality of life compared with no rehabilitation,[18] and a recent meta-analysis of 14 randomised trials found that exercise-based rehabilitation improves functional capacity and quality of life in adults after COVID-19.[19] Early exposure to these exercises may therefore have limited strength loss in our participants, although without baseline measures our design cannot confirm this.

The confidence interval for the between-group difference also helps interpret this finding. Although the study was powered to detect only large differences (about 7.9 kg), the 95% confidence interval excluded a deficit greater than 4.8 kg in the post-COVID-19 group. A substantial loss of grip strength in this sample is therefore unlikely, but a small deficit cannot be ruled out.

Absolute grip strength was low in both groups. With mean values around 25 kg in samples that were 75% men with a mean age of 41 years, both groups fell below published normative values for adults of this age[20] and below the pooled value of about 28.5 kg reported three to five months after COVID-19.[6] Methodological factors, such as the dynamometer used, testing position, hand tested or the use of mean rather than maximum values, may have lowered values in both groups equally, and normative data from Western populations may overestimate expected values in South Asian adults. Because the same protocol was applied to everyone, the between-group comparison remains valid, but absolute values should not be compared directly with normative data.

The post-COVID-19 group was taller and heavier than the control group despite age and sex matching. This difference in body size probably explains part of its higher skeletal muscle mass and longer six-minute walk distance, since taller people take longer strides. The mean walk distance of the post-COVID-19 group (484 m) was similar to the pooled value of about 495 m reported three to five months after COVID-19.[6] The longer walk distance compared with controls is therefore not evidence that COVID-19 improved functional capacity. It may also reflect rehabilitation exposure or selection of participants well enough to attend outpatient follow-up.

The most clinically relevant finding is the inverse relationship between adiposity and grip strength in the post-COVID-19 group. Grip strength fell as body fat percentage rose, whereas this was not seen in controls. Excess adipose tissue is associated with fat infiltration of muscle, low-grade inflammation and insulin resistance, all of which reduce force produced per unit of muscle.[10] The coexistence of low muscle function and high adiposity is the defining feature of sarcopenic obesity,[10] and sarcopenia has been reported in about one in five COVID-19 survivors, less often in those who remain physically active.[11] Our results suggest that grip strength was preserved in absolute terms, while the quality of muscle relative to body size may already have been affected.

The negative correlation between skeletal muscle mass and grip strength in the post-COVID-19 group was unexpected, because the two are normally positively related, as was seen, weakly, in our control group. One explanation is that bioelectrical impedance estimates muscle mass from body water,[16] and changes in hydration or inflammation-related fluid shifts during recovery from infection may distort these estimates. A second is that muscle mass in this group was partly driven by greater overall body size and adiposity rather than by contractile tissue. This finding should be treated with caution and confirmed with reference methods such as dual-energy X-ray absorptiometry.

In controls, grip strength was positively related to six-minute walk distance, body mass index and visceral fat. In a healthy sample with lower adiposity, larger body size generally comes with more muscle and greater strength. This contrast with the post-COVID-19 group supports the view that the usual relationship between body size and strength may be altered after infection. Grip strength is a well-established biomarker of general health and mortality,[7,8] and it was positively associated with walking capacity in both groups, although the association reached significance only in controls. This supports its use as a quick screening tool in post-COVID-19 follow-up, ideally together with a body composition measure.

Clinical implications

In the first month after COVID-19, a normal grip strength should not be taken as evidence of full musculoskeletal recovery. Physiotherapists should also assess body composition, and patients with high body fat may benefit from rehabilitation that combines resistance training with aerobic exercise and dietary advice, targeting both muscle function and adiposity.

Strengths and limitations

Strengths of this study include an age- and sex-matched healthy control group, assessment within a narrow early window after infection, the use of objective and standardised measures of strength, body composition and walking capacity in the same participants, and reporting of effect sizes, confidence intervals and a sensitivity power analysis. The study also has limitations. The sample was small and from a single centre, which limits statistical power and generalisability; the non-significant correlations in the post-COVID-19 group should be read in this light. No pre-infection strength data were available, so the effect of COVID-19 on each person could not be measured. Disease severity, length of hospital stay, comorbidities, physical activity level and vaccination status were not recorded, so analysis by severity was not possible. COVID-19 was excluded in controls by self-report only, so previous asymptomatic infection cannot be ruled out. Groups were matched for age and sex but differed in body size. All post-COVID-19 participants received telerehabilitation, so the effects of the infection and the intervention cannot be separated. Body composition was estimated by bioelectrical impedance, which is sensitive to hydration status. Correlation analyses were not adjusted for multiple comparisons. Finally, ethics committee approval was obtained retrospectively, after data collection.

Longitudinal studies with larger samples, stratified by disease severity and with repeated measures of strength, body composition and function, are needed to describe the course of musculoskeletal recovery after COVID-19 and to identify who benefits most from early rehabilitation.

CONCLUSION

In adults assessed 17 to 30 days after the onset of COVID-19 who had received early telerehabilitation, hand-grip strength was comparable to that of healthy age- and sex-matched controls, but body fat and visceral fat were higher. The inverse association between body fat and grip strength in the post-COVID-19 group suggests that muscle quality relative to body size, and not only absolute strength, should be monitored during recovery. Grip strength and body composition assessment, together with early rehabilitation that combines resistance and aerobic exercise, may help limit post-COVID-19 deconditioning.

DECLARATIONS

Ethics approval: The study was approved retrospectively by the Father Muller Institutional Ethics Committee, Mangaluru (protocol no. 946/2021; reference FMIEC/CCM/967/2021; dated 15 October 2021), after data collection between August 2020 and March 2021 had been completed. Written informed consent was obtained from all participants before assessment.

Conflict of interest: The authors declare no conflict of interest.

Funding: This study was self-funded and received no external funding.

Author contributions: Leah Mohandas: conceptualisation, methodology, data collection, formal analysis, writing – original draft. Roshani P: methodology, data interpretation, writing – review and editing. Cherishma D'Silva: supervision, writing – review and editing. All authors read and approved the final manuscript.

Data availability: The data supporting the findings of this study are available from the corresponding author on reasonable request.

Acknowledgements: The authors thank the participants and the staff of the Physiotherapy Department of Father Muller College of Physiotherapy for their cooperation.

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