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Original Article

Hand Grip Strength among Older Adults after COVID-19 Infection: A Cross-Sectional Analysis

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SUMMARY

Background: Hospitalisation due to COVID-19 infection leads to muscle weakness. This study aimed to evaluate hand grip strength among older adults after COVID-19 infection, and the reliability of two hand-held dynamometers.

Methods: Patients ≥ 65 years reviewed in clinic after their hospitalisation were recruited. Grip strength was assessed using hand-held dynamometer (Jamar model J00105, and Camry model EH101, hand dynamometer). Clinical information was obtained from hospital electronic medical records. Comparison was made of the two dynamometers in different participant and clinical groups. Intraclass correlation coefficient (ICC) was used to determine the inter-instrument reliability between the two dynamometers.

Results: Ninety-three participants (mean[SD] age: 73[6] years, 52.7% males) were recruited an average 55 days after discharge. 79.6% had category 4 COVID-19 (i.e. symptomatic, radiological pneumonia changes, and supplemental oxygen required). Majority (74.2%) of the participants recorded measurements lower than the threshold for low grip strength recommended by the Asian Working Group for Sarcopenia. Increasing age (r = -0.30, p = 0.003), higher Charlson Comorbidity Index score (r = -0.42, p = 0.000), and longer hospital stay (r = -0.22, p = 0.035) were associated with low grip strength. The mean (SD) grip strength was higher with Jamar dynamometer (18.1 ± 7.4 kg) than Camry dynamometer (19.5 ± 6.6 kg). Inter-instrument reliability was excellent (ICC, 0.92).

Conclusion: Low grip strength was prevalent among older people seen after COVID-19 infection. Proactive identification and management of muscle weakness is required in this group of patients.

1. Introduction

Patients with COVID-19 experience a broad spectrum of symptoms ranging from mild asymptomatic disease to severe respiratory illness with older adults being more likely to suffer from the most devastating effects of the disease.[1] Improvement of clinical symptoms tend to occur within two weeks for mild COVID-19 cases and up to six weeks for patients with severe infections.[2] However, it has been increasingly recognised that COVID-19 patients may develop wide range of long-term symptoms which persist beyond the resolution of the acute infection.[3] This is commonly described with the term 'long COVID' or 'post-acute COVID syndrome'. Whilst standardised case definition has yet to be developed, long term sequelae of COVID-19 has received much attention due to its substantial impact on patients' ability to resume normal life and their capacity to work.[4] Common manifestation of long COVID includes generalised weakness, myalgia, shortness of breath and cognitive dysfunction.[3] Several observational studies shown that up to 80% of COVID-19 patients experienced fatigue and physical deconditioning that lasted beyond 4 weeks after the initial infection.[3–5] The association of COVID-19 with anorexia, weight loss and increased muscle protein breakdown had led to a decrease in muscle function, particularly among those at risk such as older adults living with multimorbidity.[6] Restricted mobility due to bed rest and use of mechanical ventilation further aggravates the condition, resulting in development of severe muscular dysfunction during the recovery period.[7]

The recognised impact of COVID-19 on muscle function had necessitated the need for assessing muscle strength among post COVID-19 patients, especially the older population. In this context, hand grip strength is a simple and reliable surrogate of overall muscle function.[8] As a practical assessment measure, grip strength has been demonstrated to have predictive validity with its low values associated with future disability, poorer treatment response, impaired quality of life and increased mortality.[9] There are a range of hand dynamometers available to objectively measure hand grip strength. The Jamar hydraulic hand dynamometer is one widely used device which was recommended by The American Society of Hand Therapists as the gold standard measure for hand grip strength.[8] While alternative options, such as the Camry electronic dynamometer was less costly and more accessible, the use of such devices among the older population has not been widely validated. Therefore, this study was conducted to evaluate hand grip strength among post COVID-19 older patients, and the inter-instrument reli-

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ability between the Camry electronic and Jamar hydraulic dynamometers.

2. Materials and methods

2.1. Study design

This cross-sectional study was conducted at a university hospital from 7 September to 12 October 2021. This research study received approval from UMMC Medical Research Ethics Committee (MREC 2021914-10588).

2.2. Participants

Participants were recruited from the geriatric medicine-led multidisciplinary post-COVID-19 follow up clinic. Patients seen in this clinic were aged ≥ 65 years and had been admitted to the hospital for treatment for acute COVID-19 infection were recruited based on convenience sampling. Patients were assessed for their hand grip strength and this assessment was part of the routine assessment performed in this clinic. Only patients who were unable to complete the hand grip strength assessments in accordance with the standardised protocol were excluded from the study. There was no formal sample size calculation. Recruitment was based on convenience sampling of the number of people attending the outpatient clinic.

2.3. Assessment procedures

Each patient was assessed using two devices, namely the Jamar hydraulic hand dynamometer (Model J00105, Lafayette Instrument Company, USA) and Camry electronic hand dynamometer (Model EH101, Zhongshan Camry Electronic Co. Ltd. China). Assessment procedure was based on internal consensus. The hand grip strength assessments were carried out on the participant's dominant hand with three repeat measurements for each device. To avoid sequence-related fatigue effects, the alternate sequence of using the dynamometers was executed. Odd-numbered participants were tested with Jamar dynamometer first followed by Camry dynamometer with 3 to 5 minutes of rest in between devices while even-numbered participants were tested in the opposite sequence.

Following the standard procedure recommended by the American Society of Hand Therapists, participants were seated with shoulders adducted, elbow placed at 90° angle and forearm in neutral position during the assessment using Jamar hydraulic dynamometer.[10] Measurements of Camry electronic dynamometer were recorded with participants standing up with feet slightly apart and arms straight. Clear instructions were given to participants to squeeze the dynamometer as much as they could along with verbal encouragements throughout the test. Three successive readings were recorded, and the highest measurement was recorded and used for data analysis. Patient demographics and COVID-19 data were collected from each participant's electronic health records. Severity of COVID-19 was based on a locally used 5-stage category system (Category 1 – asymptomatic; Category 2 – symptomatic without radiological pneumonia changes; Category 3 – symptomatic with radiological pneumonia changes; Category 4 – symptomatic, pneumonia and supplemental oxygen required; and Category 5 – critically ill with multiorgan failure).[1]

2.4. Statistical analysis

Statistical analysis was carried out using SPSS (Version 26.0, IBM Corp., Armonk, NY, USA). Descriptive findings were presented with frequencies and percentages for categorical variables while means and standard deviations for continuous variables. Normality of the distributions was assessed visually using histograms and the Shapiro-Wilk test. Comparison of grip strength and its correlation between variables were performed using statistical tests appropriate for its distribution. These variables included patient demographics, duration of hospital stay, duration of steroid use, total steroid equivalent doses, Charlson Comorbidity Index (CCI),[11] total number of comorbidities (hypertension, diabetes mellitus, dyslipidemia, ischemic heart disease, cerebrovascular accident, chronic kidney disease, respiratory disorder, malignancy, psychiatric disorder, benign prostatic hyperplasia and others), and presence of polypharmacy (> 4 medications). Significant variables from this univariate analysis proceeded with multivariate regression analysis to investigate its independent effects on hand grip strength. Low hand grip strength was defined based on thresholds set by the Asian Working Group for Sarcopenia (AWGS) as < 28 kg for male and < 18 kg for female.[8] The total dose of corticosteroids use recorded in this study included the corticosteroids therapy received by patients during the hospital admission and after discharge from hospital. Total steroid equivalent doses were generated by converting different corticosteroid preparations to its equivalent doses of oral prednisolone.[12] Total steroid equivalent dose was dichotomised to high and low usage based on the median of the variable. Statistical significance was set at level of $p < 0.05$. Intraclass correlation coefficient (ICC) was used to determine the inter-instrument reliability between the two dynamometers with ICC > 0.90 indicating an excellent reliability. To compare the two dynamometers according to subgroups of the participants' demographics and clinical characteristics, Student's t-test and Mann-Whitney U test were performed for continuous variables with normal and non-normal distribution respectively.

3. Results

A total of 104 participants were approached during the study period. However, participants who were unable to perform the hand grip strength assessment (n = 4) and those who were not able to complete the assessment based on the recommendations of the standard protocol (n = 7) were excluded. This resulted in 93 participants recruited into the study.

Participants were assessed at an average of 55 (SD, 37) days after their discharge following COVID-19 hospitalisation. Most were in the eighth decade of life and multimorbid (Table 1).

Better hand grip strength was seen among male patients, younger age, and lower CCI score (Table 2). After multivariate linear regression analysis, age was no longer independently associated with hand grip strength, just CCI scores. Each increase in CCI score was associated with a reduction in grip strength (β = -2.12 kg, 95% CI -3.44 to -0.8, p = 0.002).

The average grip strength recorded with Jamar dynamometer (18.1 ± 7.4 kg) was lower than Camry dynamometer (19.5 ± 6.6 kg) and it was shown that there was a significant discrepancy between the two instruments ($p < 0.001$). However, measurements using both the Jamar and Camry dynamometers were found to be highly correlated to each other (R = 0.88). Additionally, the intraclass correlation coefficient (ICC) between the two devices was 0.92 which indicated an excellent inter-instrument reliability. Similar number of participants were reported with low grip strength measurements using Jamar (69, 74.2%) and Camry (68, 73.2%) dynamometers. The findings from this study also indicated that there was no significant difference of hand grip strength measurements between Jamar and

Table 1
Participant demographic and clinical characteristics (n = 93).

	Participants (n = 93)
Age, mean (SD), years	73 (6)
Gender, n (%)	
Male	49 (52.7%)
Female	44 (47.3%)
Ethnicity, n (%)	
Malay	34 (36.6%)
Chinese	41 (44.1%)
Indian	18 (19.3%)
Duration of hospital stay, mean (SD) days	12 (10)
Duration of steroid use, mean (SD) days	67 (40)
Total steroid equivalent doses, mean (SD) mg	513.71 (599.68)
Charlson Comorbidity Index, n (%)	
1–2	11 (11.8%)
3–4	57 (61.3%)
≥ 5	25 (26.9%)
Total number of comorbidities, n (%)[a]	
0	10 (10.8%)
1–2	38 (40.9%)
3–4	31 (33.3%)
≥ 5	14 (15.1%)
Polypharmacy, n (%)[b]	49 (52.7%)
Steroid use, n (%)[c]	
None	19 (20.4%)
Ongoing	6 (6.5%)
Completed	65 (69.9%)
Highest CAT, n (%)[d]	
1	2 (2.2%)
2	3 (3.2%)
3	13 (14.0%)
4	74 (79.6%)
5	1 (1.1%)
Hand dominance, n (%)	
Left	7 (7.5%)
Right	86 (92.5%)

[a]: Comorbidities recorded among participants include hypertension, diabetes mellitus, dyslipidemia, ischemic heart disease, cerebrovascular accident, chronic kidney disease, respiratory disorder, malignancy, psychiatric disorder, benign prostatic hyperplasia, and others.
[b]: Polypharmacy is defined as use of more than four medications.
[c]: Steroid use were recorded with 'None' indicating patients were not treated with steroids, 'Ongoing' denoting patients were still receiving steroids treatment on their follow up visit and 'Completed' signifying patients had completed their course of steroids treatment prior to the follow up visit.
[d]: CAT represents the 5-stage clinical category of syndrome associated with COVID-19. (Category 1 – asymptomatic; Category 2 – symptomatic without radiological pneumonia changes; Category 3 – symptomatic with radiological pneumonia changes; Category 4 – symptomatic, pneumonia and supplemental oxygen required; and Category 5 – critically ill with multi-organ failure)

Carney dynamometer recorded among male participants. Similarly, the discrepancy between the two devices was found to be not significant for the subgroups of patients more than 70 years old, treated with total steroid bioequivalent dose of ≥ 400 mg and patients with more than two comorbidities (Table 3).

4. Discussion

Hand grip strength is an important determinant of morbidity and mortality, particularly among the older adults.[13] In this study, evaluation of hand grip strength was performed on older patients with a history of COVID-19 hospitalisation. The findings of this study suggested that the majority (74.2%) of the study participants recorded measurements lower than the diagnostic cut-off for low grip strength recommended AWGS Consensus 2019.[8]

Following COVID-19 infection, presence of muscle loss with a decline in physical function was commonly observed as a consequence of the disease, especially among patients with severe COVID-19 infections.[6] This can be explained by the inflammation-mediated skeletal muscle damage, anorexia, immobilisation, and bedrest during COVID-19 hospitalisation.[14] One study reported a decline in hand grip strength by 1.72 kg among older patients with COVID-19 infection, deducing a detrimental impact of COVID-19 infection on the hand grip strength of the older population.[15]

Ageing is a progressive physiological process that leads to changes in biological functions, including an inevitable decline in skeletal muscle mass. A functionally pronounced reduction in muscle strength occurs between 50 and 60 years of age with subsequent more evident decline beyond the age of 60 years.[16] This current study demonstrated an inverse relationship between age and hand grip strength among the older post COVID-19 patients. In addition to that, a higher rate of decline in grip strength with increasing age was discovered among male participants as compared to female participants. This is in line with a previous study which reported that the estimated average grip strength for males decreased more rapidly with age than females.[17]

Comorbidities that predisposed patients to severe or critical cases of COVID-19 include hypertension, diabetes mellitus, cardiovascular disease, chronic respiratory disease, and malignancy. CCI is a reliable prognostic determinant of disease severity and mortality among COVID-19 patients.[18] This study showed an inverse correlation between CCI and grip strength among post COVID-19 older patients whereby those with higher CCI scores recorded lower grip

Table 2
Hand grip strength measurements of post COVID-19 older patients using Jamar hand dynamometer.

	n	Mean, kg	Std. deviation	Correlation coefficient	p-value
Gender				-	.000
Male	49	21.9	7.2		
Female	44	14.0	5.3		
Ethnicity				-	.081
Malay	34	19.1	7.8		
Chinese	41	18.9	7.3		
Indian	18	14.6	6.2		
Age, years	93	18.1	7.4	-0.30	.003
Duration of hospital stay, days	93	18.1	7.4	-0.22	.035
Duration of steroid use, days	93	18.1	7.4	-0.01	.942
Total steroid equivalent doses, mg				-	.881
< 400 mg	49	17.9	7.4		
≥ 400 mg	44	18.3	7.6		
Charlson Comorbidity Index	93	18.1	7.4	-0.42	.000
Total number of comorbidities	93	18.1	7.4	-0.14	.174
Highest CAT[d]	93	18.1	7.4	0.14	.179

[d]: CAT represents the 5-stage clinical category of syndrome associated with COVID-19.

Table 3
Comparison between Jamar and Camry dynamometers.

	Mean (SD), kg		Mean difference (SD)	Sig. (2-tailed)
	Jamar	Camry		
Gender				
Male	21.9 (7.2)	22.6 (6.3)	-0.7 (4.3)	.262
Female	14.0 (5.3)	16.0 (5.0)	-2.1 (2.2)	.000*
Ethnicity				
Malay	19.1 (7.8)	19.7 (6.4)	-0.6 (3.1)	.243
Chinese	18.9 (7.3)	20.2 (6.6)	-1.3 (3.6)	.021*
Indian	14.6 (6.2)	17.3 (6.7)	-2.7 (4.0)	.011*
Age, years				
≤ 70 years	19.0 (7.3)	20.7 (6.2)	-1.7 (3.1)	.001*
> 70 years	17.2 (7.5)	18.2 (6.8)	-1.0 (3.9)	.090
Duration of hospital stay, days				
≤ 10 days	18.8 (7.5)	19.9 (6.7)	-1.1 (2.9)	.010*
> 10 days	17.3 (7.4)	18.9 (6.4)	-1.7 (4.2)	.015*
Duration of steroid use, days				
≤ 55 days	18.2 (6.9)	19.6 (6.3)	-1.3 (2.7)	.002*
> 55 days	18.0 (8.1)	19.4 (6.9)	-1.3 (4.2)	.036*
Total steroid bioequivalent doses, mg				
< 400 mg	17.9 (7.4)	19.4 (7.1)	-1.4 (2.7)	.001*
≥ 400 mg	18.3 (7.6)	19.6 (6.0)	-1.2 (4.3)	.067
Charlson Comorbidity Index				
1–2	23.1 (3.6)	23.9 (3.8)	-0.8 (2.2)	.231
3–4	18.7 (7.7)	19.9 (6.5)	-1.3 (4.0)	.021*
≥ 5	14.7 (6.7)	16.4 (6.3)	-1.7 (2.8)	.005*
Total number of comorbidities				
≤ 2	18.8 (7.5)	20.0 (6.7)	-1.2 (4.1)	.050
> 2	17.4 (7.4)	18.9 (6.5)	-1.5 (2.8)	.001*
Polypharmacy				
Yes	17.5 (7.9)	18.6 (6.7)	-1.2 (3.6)	.028*
No	18.9 (6.9)	20.4 (6.3)	-1.5 (3.4)	.005*
Highest CAT[d]				
< 4	16.3 (8.5)	17.8 (8.6)	-1.5 (1.9)	.004*
≥ 4	18.6 (7.2)	19.9 (6.0)	-1.3 (3.8)	.004*
Hand dominance				
Left	22.6 (8.7)	23.9 (8.2)	-1.3 (2.4)	.193
Right	17.8 (7.3)	19.1 (6.3)	-1.3 (3.6)	.001*

[d]: CAT represents the 5-stage clinical category of syndrome associated with COVID-19.
*: Significance to p-value < 0.05.

strength measurements. In this context, an earlier study reported that patients with high CCI score were more likely to have low skeletal muscle index and physical performance depicted by a decreased gait speed.[19] While decline in skeletal muscle mass and strength is often multifactorial with involvement of complex processes, insufficient nutritional intake and physical activity are significant factors that contribute to skeletal muscle depletion, particularly among older adults with multiple comorbidities. Hence, the need to rehabilitate patients with high comorbidity burden after an acute COVID-19 infection should be considered due to the higher predisposition to development of poor muscle strength.

Duration of hospital stay can vary depending on the disease severity, underlying comorbidity and level of care required.[20] In this study, the average duration of hospital stay was almost two weeks. The majority were hospitalised with COVID-19 infection of clinical category 4 (symptomatic, radiological pneumonia changes, and supplemental oxygen required). A hospital stay of 10 to 14 days for administration of dexamethasone was recommended in accordance with the local clinical guidelines during the time the study was conducted.[1] In evaluating the impact of length of hospital stay on the patients' hand grip strength, the current study demonstrated that patients with longer hospital stay reported weaker hand grip strength. This association can be explained by the effect of bedrest, isolation precautions and physical inactivity during COVID-19 hospitalisation.[14] It has been previously reported that continuous bed rest for 10 days could potentially result in loss of 1.5 kg of whole-body lean mass and 15.6% decline in isokinetic muscle strength among healthy older adults with mean age of 67 years old.[21]

In this study, hand grip strength was assessed in an outpatient clinic using both Jamar and Camry dynamometers. A significant positive correlation was discovered between the two devices with an excellent inter-instrument reliability. In addition to that, Jamar and Camry dynamometers measured grip strength equivalently whereby similar number of participants were recorded with low grip strength readings based on the diagnostic threshold recommended by AWGS.[8] In comparison to the present study, Diaz-Munoz et al. reported a significant concordance-correlation between Jamar and Camry among the study population in Colombia, particularly among the 40–59-year-old subgroup.[22] This highlighted the importance of age as a confounding factor to variability of grip strength measurements. A recent study also performed a similar reliability and validation study between these two dynamometers.[23] It reported ICC values of 0.8, and under-reporting of grip strength with the Camry dynamometer by 0.5 kg in men and 0.6 kg in women.[23] This study employed the same grip strength assessment procedure as what was performed in this study where the Jamar was done sat down and the Camry standing up. The comparable measures between Jamar and Camry dynamometers demonstrated by this study and other published litera-

ture support the interchangeable use of the devices in assessment of hand grip strength. The alternative use of Camry dynamometer was deemed reliable for patients in the older age group.

This study has reported on hand grip strength among older adults recovering from COVID-19 infection. However, there were limitations associated with this study. This study was cross-sectional in nature whereby grip strength was assessed after the acute COVID-19 infection, without relative comparisons to the baseline grip strength of study participants. Hence, it was not able to determine how much of what was reported was due to the impact of COVID-19 or part of the patient's pre-existing health status. Furthermore, results of this study were limited by a relatively small sample size from a single university hospital. Findings obtained may not be representative for other population groups or an older population group from different hospital settings. Clinical information for this study was collected from electronic medical records. Accuracy and reliability of data collected would have been highly dependent on the clinical data entry. There were variables that were not recorded which could have influenced this study's findings. These included patients' physical frailty, nutritional status and post-COVID physical activity which would have an impact on the muscle mass and strength.

Association between hand grip strength and COVID-19 infection highlighted by this study contributed to a better understanding of post COVID-19 muscle consequences among the older population. Additionally, this study has provided foundational insights for a larger prospective observational study in the future that could provide more definitive evidence. The objective assessment of grip strength following the internationally recognised protocol ensured minimal measurement bias. This study further emphasises that low grip strength is common in this cohort, often seen in at risk group (those older and more morbid) and can easily be identified using a hand grip dynamometer. The more accessible Camry due to its lower cost compared to the gold standard Jamar could be utilised in a busy clinical setting.

5. Conclusion

Low grip strength was recorded among the older population after an acute COVID-19 infection with a significant inverse association with the increasing age, duration of hospital stay and comorbidity burden. Evaluation of muscle strength should form part of this cohort's post COVID-19 assessment with pathways linking patients to physical rehabilitation and muscle strengthening program.

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Conflicts of interest

The authors declare that they have no relevant financial or non-financial interests to disclose related to this study.

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