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ORIGINAL ARTICLE

Effects of Post-Acute COVID-19 Syndrome on Hand Grip Strength in Physiotherapists: An Anatomical Evaluation

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SARS-CoV-2,
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Muscle Strength,
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ABSTRACT

Background. Persistent symptoms and physiological disorders that occur after the acute phase of COVID-19 disease are collectively referred to as post-acute COVID-19 syndrome (PACS). **Objectives.** Symptoms that become permanent after the acute phase in individuals with COVID-19 are called PACS. This study aimed to assess the impact of COVID-19 on musculoskeletal health. **Methods.** Forty physiotherapists, with a mean age of 32.00 ± 3.58 years, participated in the study. Twenty were in the post-acute-COVID period (PCG), and 20 were in a healthy control group (HCG) who had never had COVID-19. Wrist circumferences were measured, and dominant hands were identified. Hand grip strength (HGT) was assessed with a hydraulic dynamometer, while wrist flexion and extension strength were measured with an electronic dynamometer. The results of PCG and HCG participants were compared. **Results.** Our findings show that PCG individuals had a significant decrease in grip strength in their non-dominant left hand (32.18 ± 5.21 kg) compared to the HCG group (36.38 ± 4.81 kg; $p<0.05$), while no significant differences were observed in right-hand grip strength (PCG: 33.93 ± 5.68 kg; HCG: 37.37 ± 4.75 kg; $p>0.05$) or isometric muscle strength. The decreased left-hand grip strength was interpreted as compensating for the loss of strength on the dominant side by using the dominant hand more frequently after the illness. **Conclusion.** The data suggest that COVID-19 may lead to decreased muscle performance rather than direct structural impairments. In particular, left-hand grip strength was significantly reduced by 4.2 kg (PCG: 32.18 ± 5.21 kg vs. HCG: 36.38 ± 4.81 kg; $p<0.05$), whereas no significant difference was observed in right-hand grip strength or isometric muscle strength. Although wrist circumference was significantly smaller in PCG participants ($p < 0.05$), the lack of a significant difference in the Extension Contraction Test (ECT) suggests that functional recovery of frequently used muscle groups is possible after the illness. These findings are crucial for designing effective rehabilitation strategies and informing future research.

INTRODUCTION

The novel coronavirus disease (COVID-19) outbreak, triggered by SARS-CoV-2, emerged in 2019 and rapidly became a global pandemic (World Health Organisation). The lasting effects of COVID-19, which show a clinical course ranging from mild symptoms to death, on human health are still the subject of research today. Permanent symptoms such as loss of taste and

smell (1, 2) as well as shortness of breath, sleep disorders (3, 4), dyspnoea, and cough are some of the symptoms reported in people who have had the disease (5). The duration and form of symptoms vary in individuals who have had the disease (6). Persistent muscle fatigue is a common symptom experienced by individuals who have had COVID-19. Studies have shown that some patients experience physical performance impairment after COVID (7, 8). In a study of patients discharged six months after acute infection, fatigue, muscle weakness, and decreased physical performance were among the symptoms reported (9-11).

During the pandemic, many occupational groups transitioned to remote work to protect themselves from the virus; physiotherapists, like other healthcare professionals, had to continue working in close contact with patients who were infected or at risk of infection during this period. For this reason, physiotherapists have been a professional group working under risk for the symptoms mentioned above. Among these symptoms, we believe that muscle fatigue and changes in the flexor-extensor muscle groups are the symptoms that physiotherapists are most likely to experience professionally. Physiotherapists actively engage the muscles of the arm and forearm region during rehabilitation sessions. Muscle fatigue may decrease muscle strength by reducing the ability of muscles to produce power, which negatively affects performance in activities that require power. In short, the decrease in muscle strength of physiotherapists may negatively affect work efficiency (12-14).

Musculoskeletal symptoms, including reduced muscle strength, fatigue, and physical deconditioning, are among the most frequently reported consequences of post-acute COVID-19 syndrome (PACS). While the lower limb and trunk musculature are often evaluated in general functional capacity studies, handgrip and wrist muscle strength have emerged as sensitive and reliable indicators of musculoskeletal health, particularly in clinical populations experiencing systemic illness, frailty, or disuse atrophy. Handgrip strength, in particular, is a well-established surrogate marker for overall muscle strength, functional independence, and even long-term health outcomes. Recent studies have highlighted the importance of assessing peripheral muscle strength, particularly handgrip, in PACS, underlining its clinical utility in monitoring recovery and identifying patients at risk of prolonged functional impairment (15). Therefore, wrist and hand muscle strength were prioritized in our study as accessible and objective measures to reflect the musculoskeletal consequences of COVID-19, providing both clinical relevance and comparability with existing literature.

MATERIALS AND METHODS

Study Design. This cross-sectional study was conducted between January 1, 2023, and June 30, 2023. Ethics committee approval was obtained from the Kocaeli University Non-interventional Research Ethics Committee (Approval Number: 2022/378). The study design focused on comparing musculoskeletal outcomes between physiotherapists who had previously been infected with COVID-19 and those with no history of infection. Due to the design's nature, no longitudinal follow-up was conducted; this limitation is acknowledged, especially considering the prolonged recovery patterns often observed in post-acute COVID-19 syndrome (PACS).

Participants. Forty volunteer male physiotherapists (mean age, 32.00 ± 3.58 years) participated in the study. Twenty were included in the Post-COVID group (PCG) and the other twenty in the healthy control group (HCG), with both groups matched in terms of age and body mass index (BMI) to ensure comparability (Figure 1). Including only male participants was a deliberate methodological choice to reduce sex-based variability in muscle strength and neuromuscular characteristics; however, this approach limits the generalizability of the findings and is acknowledged as a study limitation.

Participants were randomly selected from different hospitals and private clinics in Kocaeli, Turkey. Individuals were excluded if they had a history of upper extremity injury or trauma, were not actively practicing, or had less than five years of professional experience.

For the PCG, the time elapsed since the COVID-19 diagnosis ranged between 3 and 12 months prior to the study. All PCG participants had experienced mild to moderate symptoms during the acute infection phase, and none had required hospitalization or oxygen therapy.

Potential confounding variables were also considered: participants with a history of corticosteroid use, systemic comorbidities (e.g.,

diabetes mellitus, cardiovascular diseases, chronic lung conditions), or other musculoskeletal disorders were excluded to minimize bias in the results.

To ensure the adequacy of the sample size, a priori power analysis was conducted using G*Power 3.1 software. Based on an independent samples t-test (two-tailed) with α=0.05, an expected medium effect size (Cohen's d=0.65), and a total sample of 40 (20 per group), the calculated power was 0.84 (84%), confirming that the study was sufficiently powered to detect significant group differences in primary musculoskeletal outcomes.

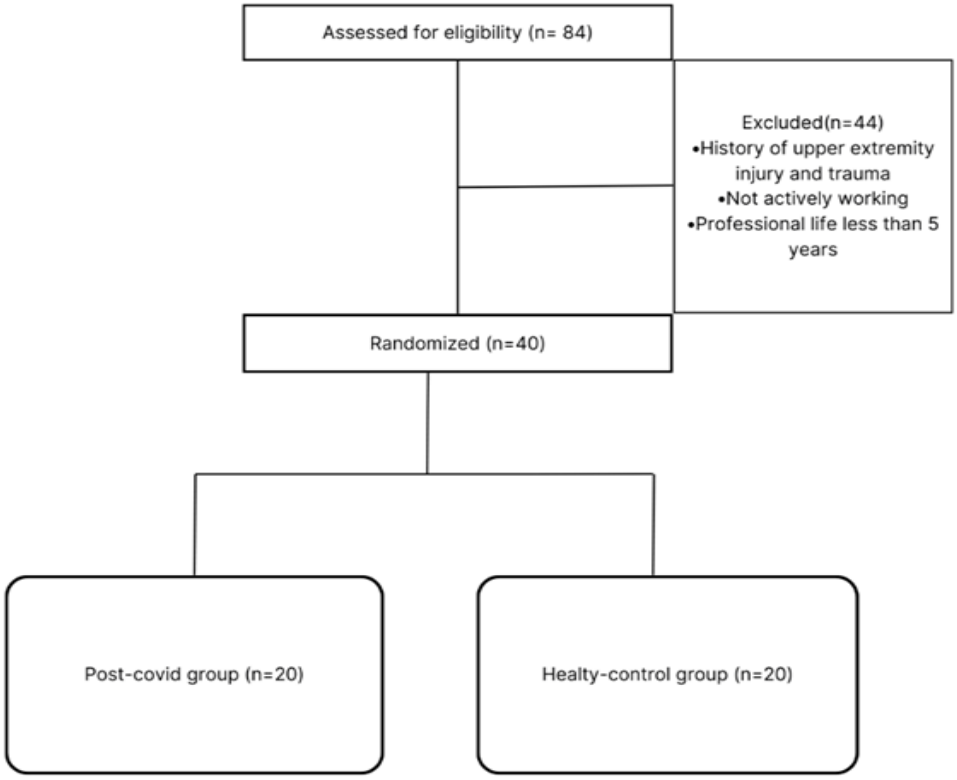

Figure 1. Flow chart of participant recruitment and group allocation.

Data Collection Tools. The participants' data were recorded on detailed measurement forms.

The wrist circumference of the participants was measured by using a tape measure to record both wrist circumferences (right and left). The Oldfield Hand Preference Test (10) was applied to the participants to determine the dominant hand preference of the subjects included in our study.

Hand Grip Strength (HGF) Measurements. The hand grip strength (HGS) of the participants was measured using the Jamar Hydraulic Hand Dynamometer (Model No. 5030J1, Sammons Preston, Bolingbrook, IL, USA), as recommended by the American Association of Hand Therapists (AETD) (11). The device has been calibrated regularly to ensure accuracy and provides consistent readings of hand grip strength in pounds or kilograms. The Extension Contraction Test (ECT) was measured as recommended by the AETD (Figure 2). The grip test was repeated three times for each hand. The measurements were taken with three repetitions, each with a 10-second interval, and the average value of the three measurements was calculated. The force obtained was noted in kg.

The participants' isometric (flexion/extension) muscle strength was measured using an Electronic Push/Pull Dynamometer (EPPD).

Figure 2. Grip force measurement with Jamar hydraulic hand dynamometer.

The participants' isometric (flexion/extension) muscle strength was measured using an Electronic Push/Pull Dynamometer (EPPD). EPPD measurements for each wrist were repeated three times with one-minute intervals between each measurement, and the average value was recorded. During the flexion strength test, the dynamometer was applied to the palmar surface of the distal phalanges with the wrist in a neutral position. For the extension strength test, the dynamometer was applied to the dorsal surface of the distal phalanges. Wrist flexion measurements are presented in Figure 3, while extension measurements are shown in Figure 4.

Figure 3. Wrist flexion measurement electronic push/pull dynamometer (EPPD).

Figure 4. Wrist extension measurement using an electronic push/pull dynamometer (EPPD).

The Electronic Push/Pull Dynamometer (EPPD) was used to measure isometric (flexion/extension) muscle strength (Figure 2). The EPPD measurements of the participants were repeated three times for each wrist, with one-minute intervals between each measurement, and the mean value was recorded.

Data Analyses. The collected data were analysed using SPSS statistical software (version 22.0). Mean and standard deviation values were calculated for hand grip strength, wrist circumference, and BMI. An independent sample t-test or Mann-Whitney U test was used for intergroup comparisons. Pearson or Spearman correlation coefficients were used for correlation analysis. Statistically significant values were determined at a significance level of $p < 0.05$.

RESULTS

The findings of this study reveal the potential effects of COVID-19 on hand grip strength and other musculoskeletal parameters among physiotherapists. Forty physiotherapists, 20 PCG, and 20 HCG, were included in our study. All subjects were right-handed. The age and BMI values of the subjects are presented in Table 1. The age, height, weight, and BMI values of the subjects are presented in Table 1.

Table 1. BMI comparison between groups.

Parameter	HCG (n=20) Mean ± SD [95% CI]	PCG (n=20) Mean ± SD [95% CI]	P Value
Age (years)	31.60 ± 3.79	32.40 ± 3.42	0.488
Height (cm)	176.90 ± 5.04	177.95 ± 4.30	0.482
Weight (kg)	74.70 ± 6.14	74.30 ± 12.36	0.593
BMI (kg/m^2)	23.86 ± 1.47	23.47 ± 3.97	0.698

BMI: Body mass index; PCG: Post-COVID-19 group; HCG: Healthy control group.

No statistically significant differences were found between the PCG and HCG groups in terms of age, height, weight, or BMI ($p > 0.05$). The 95% confidence intervals also indicate a consistent overlap, supporting the absence of significant group differences. The grip strength values of the right and left hands of the participants are given in Table 2. Although no statistically significant difference was observed in right-hand grip strength between the groups ($p>0.05$, 95% CI overlaps), left-hand grip strength was significantly lower in the PCG group compared to the HCG group ($p<0.05$, 95% CI did not overlap).

Table 2. Hand grip strength comparison between groups.

	PCG (Mean ± SD) (kg)	HCG (Mean ± SD) (kg)	P Value	95% CI
Right Hand	33.93 ± 5.68	37.37 ± 4.75	p>0.05	[-8.05, 0.25]
Left Hand	32.18 ± 5.21	36.38 ± 4.81	p<0.05	[-7.97, -0.49]

PCG: Post-COVID group; HCG: Healthy control group.

As shown in Table 1, the right-hand grip strength of physiotherapists who had contracted COVID-19 did not show a statistically significant difference compared to those who had not ($p > 0.05$). However, left-hand grip strength was significantly lower in those with COVID-19 ($p<0.05$).

Our findings show that PCG individuals had a significant decrease in grip strength in their non-dominant left hand (32.18 ± 5.21 kg; 95% CI: 30.15–34.21 kg) compared to the HCG group (36.38 ± 4.81 kg; 95% CI: 34.12–38.64 kg; $p<0.05$). No significant differences were observed in right-hand grip strength (PCG: 33.93 ± 5.68 kg; HCG: 37.37 ± 4.75 kg; $p>0.05$) or isometric muscle strength. The decreased left-hand grip strength was interpreted as a compensatory mechanism for the loss of strength on the dominant side, where the dominant hand was used more frequently after the illness.

Table 3 describes the findings regarding wrist circumference measurements. Table 3 shows a significant difference in wrist circumference between the right and left wrists among individuals who had COVID-19 and those who did not. The wrist circumference of those with COVID-19 was significantly lower than that of those without.

Isometric muscle strength measurements are presented in Table 4. Individuals who have had COVID-19 appear to have a reduction in extension strength compared to their HCG counterparts, but this difference is not statistically significant.

Table 3. Comparison of mean, standard deviation, and difference between groups for wrist circumference and hand length.

Variable	PCG (Mean ± SD)	HCG (Mean ± SD)	P Value
Right Wrist Circumference (WC)	16.95 ± 1.47 cm	18.05 ± 1.57 cm	p<0.05
Right Hand Length (HL)	17.00 ± 1.49 cm	19.15 ± 1.93 cm	p<0.05
Left Wrist Circumference (WC)	16.95 ± 1.47 cm	18.05 ± 1.57 cm	p<0.05
Left Hand Length (HL)	17.05 ± 1.47 cm	19.15 ± 1.57 cm	p<0.05

PCG: Post-COVID group; HCG: Healthy control group; WC: Wrist circumference; HL: Hand length.

Table 4. Wrist grip strength comparison (Jamar data).

	PCG (Mean ± SD)	HCG (Mean ± SD)	P Value
Right Hand Jamar (kg)	33.93 ± 5.68	37.37 ± 4.75	p>0.05
Left Hand Jamar (kg)	32.18 ± 5.21	36.38 ± 4.81	p<0.05

PCG: Post-COVID group; HCG: Healthy control group.

These findings make an important contribution to understanding the potential effects of COVID-19 on physiotherapists' handgrip strength and musculoskeletal health.

No statistically significant differences were found in right-hand grip strength comparisons. However, PCG in left-hand grip strength suggests that physiotherapists experience a decline in left-hand muscle strength, which may affect their professional performance.

When anthropometric measurements were evaluated, PCG physiotherapists' wrist circumference and hand length values were significantly lower than those of HCG physiotherapists. This can be interpreted as the disease affecting the physical structure of the wrist area. Although the wrist circumference on the dominant side of the PCG participants was significantly smaller than that of the HCG participants, the fact that no significant difference was found in the Extension Contraction Test (ECT) on the same side suggests that the performance of actively used muscle groups can be increased again after the disease.

There was no statistically significant difference in BMI values between the Post-COVID and healthy control groups (Figure 5). While the right-hand grip strength did not significantly differ, the left-hand grip strength was significantly lower in the post-COVID group than in the control group (Figure 6). Both wrist circumference and hand length were significantly lower in the post-COVID group than in the healthy controls (Figure 7). The Jamar dynamometer results showed a significant reduction in left-hand grip strength in the post-COVID group, while the right-hand difference was insignificant (Figure 8).

Additionally, significant changes were observed in isometric muscle strength measurements. It was observed that PCG physiotherapists exhibited a significant decrease in extension strength; however, this difference was not statistically significant. This finding suggests that the disease affects the muscle function of physiotherapists, with more pronounced changes observed in specific muscle groups.

These findings represent an important step in understanding the impact of COVID-19 on the musculoskeletal health and occupational performance of physiotherapists. It is essential to consider these findings in terms of organizing rehabilitation processes and professional practices following the disease.

DISCUSSION

Our study was planned to examine the potential effects of COVID-19 on muscle and grip strength. For this purpose, physiotherapists, a professional group that frequently uses muscle strength and ECT due to their profession, were included in the study.

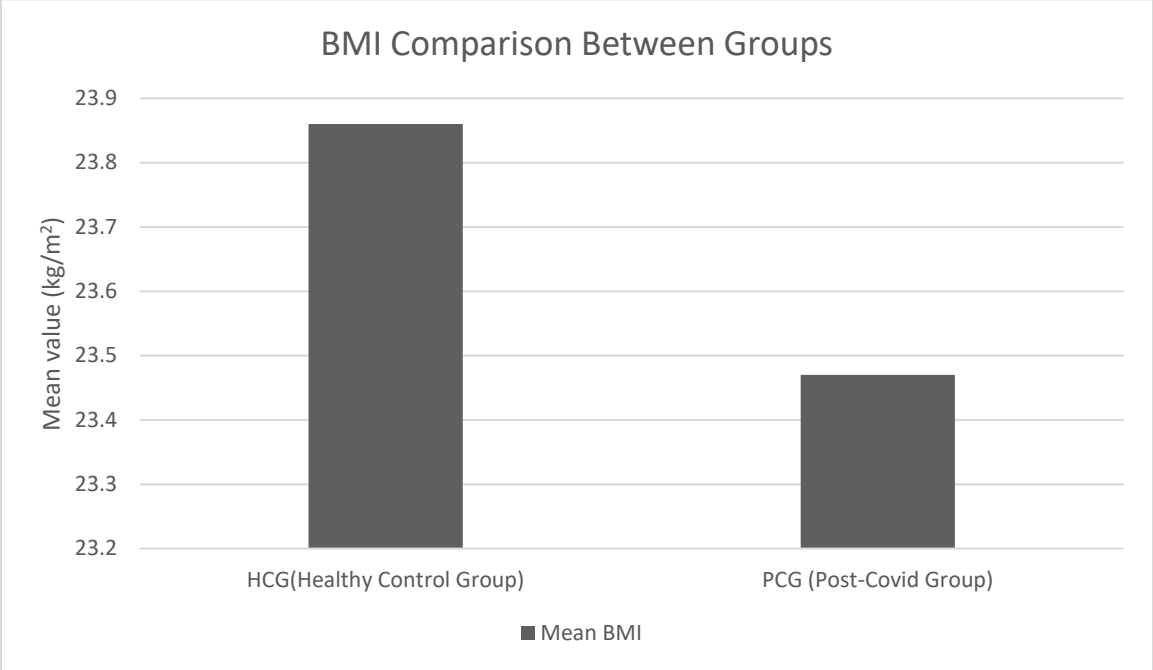

Figure 5. BMI comparison between groups.

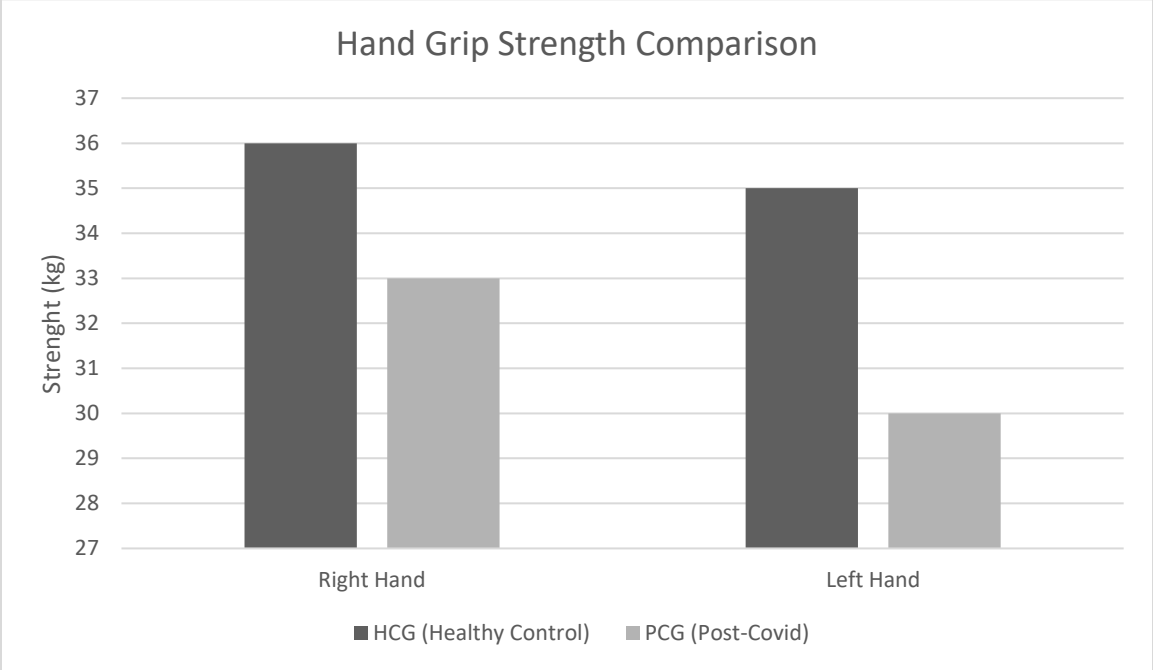

Figure 6. Hand grip strength comparison.

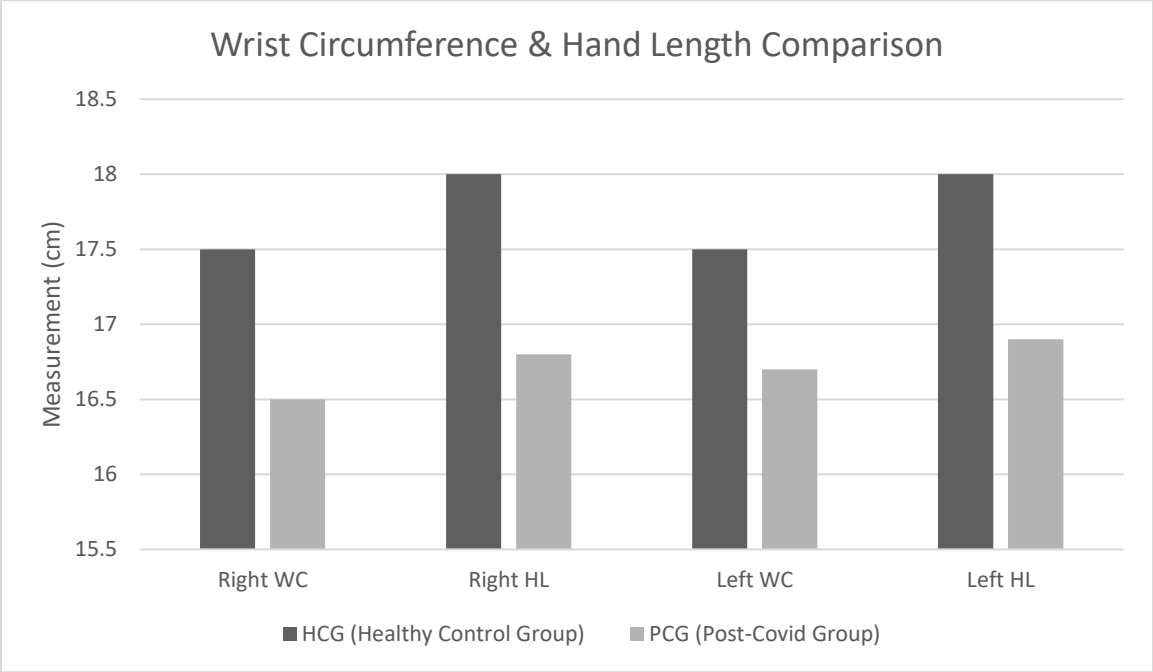

Figure 7. Wrist circumference and hand length comparison.

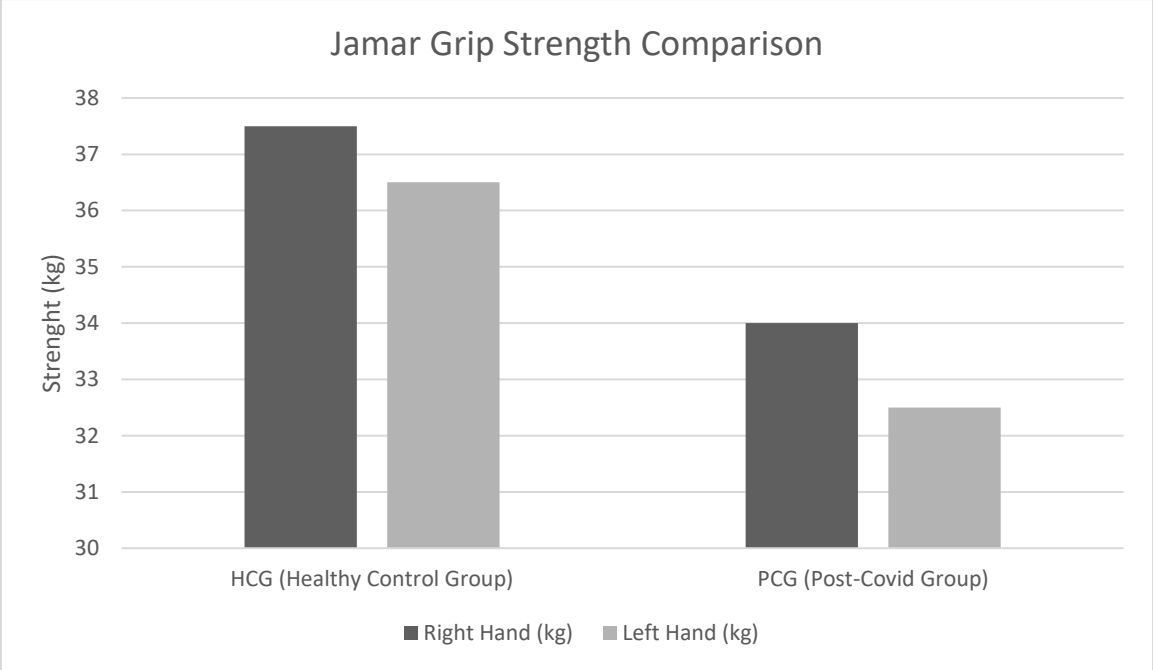

Figure 8. Jamar grip strength comparison.

Some studies have reported symptoms affecting the musculoskeletal system in individuals infected with COVID-19. Fatigue, myalgia, and neck pain are some of them. In a study of patients in the acute phase of the disease, joint pain was reported in 23.7% of patients after discharge (16-18).

The causes and treatment options of COVID-19 symptoms affecting the musculoskeletal system, such as chronic fatigue, are still being investigated today (16). Studies investigating the rehabilitation of various muscle groups following COVID-19 and the management of COVID-19 symptoms have

garnered attention in recent years. For example, a 2020 study reported positive improvements in symptoms following rehabilitation of pulmonary muscles in patients during the acute phase, as well as in those who were on ventilators after contracting COVID-19 (17). Our study found that PCG physiotherapists experienced a loss of grip strength; however, the loss of grip strength in the non-dominant hand was significantly greater than in the dominant hand. This can be interpreted as that functions can be recovered in muscle groups exercised continuously and more frequently in patients post-acute.

According to the data obtained from our findings, significant decreases in wrist circumference and hand length, as well as decreases in ECT in the dominant hand, were determined in PCG with COVID-19. These results are consistent with studies conducted on individuals with SARS-CoV-1 infections and suggest that the disease may potentially affect the musculoskeletal system. In particular, previous studies showing decreased hand grip strength in individuals with SARS-CoV-1 infections suggest that individuals with COVID-19 may experience similar problems (19). According to another study conducted in post-COVID individuals, muscle weakness and myalgia were reported in 25% of patients (1, 20).

Individuals with high muscular endurance are thought to be more resistant to repetitive overuse. Hand grip strength is important as it reflects physical work capacity and general health (21). Therefore, decreases in hand grip strength may affect physiotherapists' ability to fulfill their professional duties. The fact that physiotherapists have to work in direct contact with patients during the COVID-19 pandemic makes the importance of these decreases in hand grip strength even more evident. Furthermore, considering the relationship between the physical workload of physiotherapists and their professional practice, it is conceivable that decreases in handgrip strength among those who have COVID-19 may affect their professional performance.

In some studies, corticosteroid treatment, previously used during the SARS-CoV-1 outbreak, has been associated with decreased bone mineral density and muscle fatigue. Although similar treatments were employed during the COVID-19 pandemic, our study did not include an analysis of the specific treatment regimens received by the participants. Therefore, no direct conclusion regarding corticosteroid-related musculoskeletal effects in our Post-COVID group can be drawn. Nevertheless, considering the potential impact of corticosteroids on the musculoskeletal system reported in earlier studies, future research should monitor treatment history in more detail and investigate its relationship with grip strength and isotonic muscle function in post-COVID populations.

The absence of COVID-19 severity data is another limitation of our study. Future studies should consider the severity of the disease as a variable, as individuals with more severe symptoms may experience different long-term musculoskeletal impacts compared to those with mild or asymptomatic cases.

The results of our study highlight reductions in hand grip strength among individuals who have had COVID-19. However, this reduction is only evident in some measures. For example, no significant differences were observed in right-hand Jamar values. This may suggest that the effects of COVID-19 on hand grip strength are more pronounced in the non-dominant hand, possibly due to compensatory overuse of the dominant hand.

This compensation hypothesis may be related to increased mechanical use and neuromuscular adaptation mechanisms involving motor control. Although our study did not directly assess motor coordination or neuromotor function, the preservation of dominant hand strength could be attributed to altered motor recruitment strategies or cortical reorganization following the illness. Further studies incorporating motor control assessments would help to elucidate this hypothesis.

Furthermore, significant differences were observed in anthropometric measurements such as left wrist circumference and left hand length. These findings suggest that the musculoskeletal effects of COVID-19 may vary across different anatomical and functional parameters.

An unexpected finding in our study was a decrease in wrist circumference in the Post-COVID group. While participants with known musculoskeletal disorders, systemic diseases, or previous upper extremity injuries were excluded, the reduction could be related to subclinical muscle atrophy or resolution of soft tissue edema following infection. However, since no imaging techniques (such as MRI or ultrasound) or

follow-up measurements were included in our study, the underlying cause of this finding remains speculative. Therefore, further research incorporating imaging techniques and longitudinal data is needed to confirm the clinical significance of this result.

One of the key limitations of this study is the small sample size (n), which may restrict the ability to generalize the findings to a larger population. A larger sample size would be essential in future studies to validate and extend the results of this study. The absence of COVID-19 severity data is another limitation of our study. Future studies should consider the severity of the disease as a variable, as individuals with more severe symptoms may experience different long-term musculoskeletal impacts compared to those with mild or asymptomatic cases. It is important to consider the possibility of disuse versus disease as alternative explanations for the observed reductions in grip strength and muscle function. Post-illness alterations in activity levels may also contribute to the observed outcomes, and further research should explore these two factors in greater depth.

Recent studies in PACS (Physical Activity and Chronic Stress) have highlighted the role of muscle mass in strength recovery post-COVID (22). Demonstrated that reduced muscle strength in patients with long-COVID syndrome is mediated by limb muscle mass. These findings suggest muscle mass loss may be a key mediator of strength reductions in patients recovering from COVID-19.

CONCLUSION

Our study provides valuable insights into the functional aspects of musculoskeletal health in patients with COVID-19. It was significant that physical performance lost during the post-COVID period was regained through exercise targeting the affected muscle groups. However, we recognize that our study's sample was limited, as it included only physiotherapists from a specific region. Therefore, the generalizability of our findings may be restricted.

We have revised our conclusions to reflect our data more accurately, and we have replaced references to "impairments in physical structure" with "impairments in physical function" to avoid overstating functional data without structural evidence (e.g., imaging). Regarding recovery, we have softened the language and clarified that while recovery in physical performance was observed, longitudinal support for complete recovery is still needed.

The data from our study provide a foundation for future research to be conducted with larger and more diverse populations. Future studies should further investigate the long-term effects of COVID-19 on musculoskeletal health and develop targeted interventions to mitigate potential adverse effects. By prioritizing the health and safety of healthcare professionals, we can increase the resilience of healthcare systems in the face of current and future challenges.

Additionally, based on our data, we suggest incorporating physical activity into post-COVID treatment protocols to improve patient outcomes.

Despite its valuable findings, this study is limited by its male-only sample, cross-sectional design, lack of longitudinal follow-up, and the absence of data regarding time since COVID-19 infection in the post-COVID group. Future studies with larger, more diverse populations and prospective designs are needed to validate and expand upon these results.

APPLICABLE REMARKS

- The findings of this study highlight the impact of post-acute COVID-19 syndrome (PACS) on musculoskeletal performance, particularly hand grip strength, in physiotherapists.
- A significant reduction in left-hand grip strength was observed in individuals recovering from COVID-19, suggesting a possible compensatory overuse of the dominant hand during the post-acute phase.
- These results underscore the importance of incorporating bilateral strength assessments and targeted rehabilitation protocols into post-COVID recovery programs for healthcare professionals.
- Functional recovery appears feasible in commonly used muscle groups, but strength imbalances may persist.
- Physiotherapists, occupational therapists, and rehabilitation specialists should consider evaluating grip strength and muscle symmetry as part of routine post-COVID functional assessments, even in young and active populations.

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AUTHORS' CONTRIBUTIONS

Study concept and design: Mehtap Erdogan. Acquisition of data: Gazmend Rahova, Mehtap Erdogan. Analysis and interpretation of data: Serap Çolak, Mehtap Erdogan. Drafting the manuscript: Mehtap Erdogan. Critical revision of the manuscript for important intellectual content: Tuncay Çolak, Serap Çolak. Statistical analysis: Serap Çolak. Administrative, technical, and material support: Gazmend Rahova, Tuncay Çolak. Study supervision: Mehtap Erdogan, Tuncay Çolak, Serap Çolak.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest (The responsible author owns all illustrations in this work).

FINANCIAL DISCLOSURE

There are no financial interests related to the material in the manuscript.

FUNDING/SUPPORT

It did not receive any financial or material support for the research and work, nor was it limited to grant support, funding sources, and the provision of equipment and supplies.

ETHICAL CONSIDERATION

Informed consent was obtained from each patient included in the study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki, as reflected in the prior approval obtained from the institution's human research committee.

ROLE OF THE SPONSOR

There are no sponsors for this study.

ARTIFICIAL INTELLIGENCE (AI) USE

This study did not utilize AI or AI-assisted tools.

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