

## ORIGINAL ARTICLE

# Rehabilitation for Patients with COVID-19: A Japanese Single-center Experience

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**Objectives:** The aim of the study was to describe the characteristics and efficiency of rehabilitation for patients diagnosed with moderate-to-severe coronavirus disease (COVID-19). **Methods:** We retrospectively assessed the medical records of patients with COVID-19 who underwent rehabilitation for early mobilization and to maintain activities of daily living at our hospital between April 21 and August 20, 2020. The following patient data were evaluated: age, sex, diseases, and the total number of sessions completed by patients with severe COVID-19 in the intensive care unit (ICU) and by patients with moderate disease in the general COVID-19 wards. The number of daily sessions performed by physiotherapists was also evaluated. **Results:** Of 161 patients with COVID-19 admitted during the study period, 95 underwent rehabilitation (78 in the general COVID-19 wards and 17 in the ICU). These 95 COVID-19 patients completed 1035 rehabilitation sessions in total (882 in the general ward and 153 in the ICU). Polymerase chain reaction test results for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) were positive for 79 patients on the initiation of rehabilitation. Moreover, 86 sessions were supervised remotely, thereby reducing the duration of the medical staff's stay in the SARS-CoV-2 isolation area. Patients with COVID-19 in the ICU received significantly more daily physiotherapy sessions than general ward patients ( $P < 0.001$ ). Each physiotherapist performed, on average, 4.6 sessions daily, with 4.3 daily sessions being performed wearing personal protective equipment (PPE). **Conclusions:** COVID-19 rehabilitation required more efforts as wearing PPE was necessary for most cases although tried with remote rehabilitation in some cases. Overall, a longer rehabilitation period was needed for ICU patients.

**Key Words:** coronavirus disease 2019; infection; physiotherapy; rehabilitation; risk management

## INTRODUCTION

The coronavirus disease (COVID-19) pandemic has affected people worldwide and is a serious problem because of its virulence and mortality risk. However, reports on the rehabilitation of patients with COVID-19 are limited.<sup>1)</sup> Rehabilitation interventions for patients with severe COVID-19 requiring ventilatory support generally involve a particular skillset acquired through specialist training, particularly in the acute phase.<sup>2,3)</sup>

To prevent nosocomial severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections, and to limit the use of personal protective equipment (PPE), the current COVID-19 guidelines do not recommend active rehabilitation. The exceptions are respiratory physiotherapy in the intensive care unit (ICU) for patients with severe symptoms, and mobilization, exercise, and rehabilitation of frail patients with multiple comorbidities or significant risks of developing functional limitations.<sup>4)</sup> A recent set of guidelines from France demonstrated the possibility of remote rehabilitation

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**Fig. 1.** Physiotherapists wearing personal protective equipment.

via telecare to facilitate physiotherapy or rehabilitation at home.<sup>5)</sup>

In Tokyo, the number of patients with COVID-19 has been increasing since the beginning of April 2020. Our hospital, the Tokyo Medical and Dental University, located in the center of Tokyo, started admitting patients with COVID-19 from April 2, 2020, onwards. Our role was to treat moderate-to-severe patients with COVID-19 requiring oxygen supplementation and intensive care interventions, including intubation, hemodynamic monitoring, and extracorporeal membrane oxygenation (ECMO). Initially, to avoid hospital-acquired infections and preserve PPE supplies, we planned to provide late-phase rehabilitation only for COVID-19 survivors because an increase in COVID-19 cases was expected, as had been observed in other countries. However, two cases of pulmonary embolism<sup>6)</sup> caused by hypercoagulability and hyperinflammation associated with COVID-19<sup>7-9)</sup> occurred as soon as we began to admit patients. Subsequently, we started providing early rehabilitation for patients with COVID-19, regardless of the patients' polymerase chain reaction

(PCR) test results, thereby improving respiratory function by counteracting immobilization that could lead to decreased muscle strength, insufficient sputum drainage, increased risk of deep vein thrombosis or pulmonary embolism, as well as addressing neuropsychological issues. It was hoped that these measures would promote the recovery of ICU survivors from critical illness both in the ICU and in the general wards.<sup>10,11)</sup>

We previously reported that rehabilitation therapy effectively improved the activities of daily living (ADLs) of patients with COVID-19.<sup>12)</sup> We routinely performed conventional one-to-one direct rehabilitation therapy. However, to minimize contact and the time spent with patients with COVID-19, we devised a remote rehabilitation modality using a mobile terminal.<sup>12)</sup> Nevertheless, to avoid hospital-acquired infections, doctors and physiotherapists wore full sets of PPE while conducting direct rehabilitation therapy (**Fig. 1**).<sup>4)</sup> A full set of PPE included a disposable fluid-resistant long-sleeved gown, an N95 mask, goggles or a face shield, a cap, and double-gloves. Donning a full set of PPE takes substantial time and effort, although it is required to prevent disease

transmission. Staff members were trained in the correct way to don and doff PPE, including N95 “fit-checking.” This study aimed to describe the characteristics and efficiency of rehabilitation for patients with COVID-19.

## METHODS

### Study Setting

The Tokyo Medical and Dental University is a general acute care hospital with 814 beds. For COVID-19 treatment, by temporarily closing two wards, we took measures to prepare two dedicated general wards and an ICU for patients with a confirmed diagnosis of COVID-19. Initially, diagnosis of SARS-CoV-2 infection was made only at Japanese Public Health centers before admission to our hospital. Subsequently, PCR-positive patients from our fever outpatient department were also admitted. Patients with mild symptoms requiring no oxygen therapy and patients with moderate symptoms requiring oxygen therapy (up to 5 l/min) with a history of mild or current few-to-light signs of pneumonia on computed tomography were admitted to the general COVID-19 wards. At our hospital, asymptomatic patients and those with mild symptoms were followed up with X-rays, blood tests, and PCR tests to monitor the course of the disease. Remdesivir or favipiravir was administered to patients with deteriorating X-ray findings or to those with severe symptoms requiring oxygen therapy (up to 5 l/min). Favipiravir, an anti-influenza drug, was administered with patients' consent after informing them about the adverse effect of teratogenicity. Patients also received ciclesonide, an inhaled corticosteroid used to treat asthma, along with conventional oxygen therapy. In patients with hypercoagulability, anti-coagulants (internal use of rivaroxaban or intravenous administration of heparin) were administered according to the D-dimer and C-reactive protein concentrations. Patients requiring oxygen therapy (more than 5 l/min) were accommodated or transferred to the ICU to be intubated or treated with respiratory management and intensive care. Survivors were transferred from the ICU to the general ward after extubation as soon as their respiratory condition improved following extubation or ECMO treatment. After extubation when intensive care was no longer needed and before the initiation of rehabilitation, some cases were referred back to the hospital to which they were previously admitted.

We formed a COVID-19 rehabilitation team with one rehabilitation doctor and several physiotherapists. At the time of admission to the COVID-19 general wards or ICU, which were in an isolated area, each patient's general status and

level of physical activity were evaluated by the rehabilitation doctor, and rehabilitation therapy was prescribed following the exclusion criteria. The initiation of rehabilitation could also be requested by the rehabilitation doctor, depending on the patient's condition. Rehabilitation therapies were started immediately after admission to the general wards and consisted of the following: verticalization, sitting on the edge of the bed, standing, walking, and active muscle training. In the ICU, we did not perform active respiratory physiotherapy because the patients were intubated for connection to a mechanical ventilator, vascular access for ECMO, or continuous hemofiltration. Moreover, some patients were in the prone position. Nurses acted on behalf of physiotherapists when patients were sedated or for prone position therapy in patients with a Richmond agitation sedation scale score  $\leq -2$ . The scope of this rehabilitation was range of motion (ROM) exercises or positioning under the rehabilitation doctor's control. When sedation was reduced, physiotherapists performed rehabilitation. In the COVID-19 ICU, verticalization, sitting on the edge of the bed, standing, walking, and active muscle training were started once the patient was extubated.

In the COVID-19 general wards, direct rehabilitation with assistance was selected at the start of rehabilitation, and if the patient met the criteria for remote rehabilitation, direct rehabilitation was switched to remote rehabilitation. Our remote rehabilitation consisted of active muscle training on standing or stepping. During direct rehabilitation, the remote rehabilitation regimen of active muscle training on standing or stepping was performed if conditions allowed.

The criteria for implementing remote rehabilitation were as follows: no requirement for oxygen therapy, oxygen saturation (SpO<sub>2</sub>)  $\geq 94\%$ ; no venous bloodline; able to stand independently; able to perform light squatting in a controlled manner; no comorbidities such as uncontrolled arrhythmia or high blood pressure; the ability to follow orders (no decreased level of consciousness or delirium); Japanese speaker, even if not native;  $<70$  years old; and consent given to undergo remote rehabilitation.

In the COVID-19 general wards, we installed four Wi-Fi-connected iPad terminals (two in the infected zone: red zone, two in the clean zone: green zone) for communication between the physical therapist in the clean nurses' station (green zone) and the patient or nurse wearing a full set of PPE in the patient's room (red zone). Two of these terminals were used during remote rehabilitation—one was used by a physiotherapist in the green zone and the other, which was delivered to the patient's bedside during rounds, was used by the patient in the red zone. The physiotherapist observed the



patient from the green zone using one of the iPad tablets. The iPad tablets used in the red zone never crossed paths with those used in the green zone; the red-zone iPads remained exclusively in the red zone to prevent any cross-contamination. Apart from separating the iPads used in these two zones, no particular hygiene regimen was followed once the iPads were inside the red zone. The physical therapist in the green zone was able to have a full-body view of the patient in the red zone and to speak with him or her. We investigated the remote rehabilitation performed with patients in the red zone by the physical therapist in the green zone using the iPad's audio and video functions. Remote rehabilitation therapy was evaluated by monitoring the SpO<sub>2</sub> and heart rate using a finger oximeter and by noting the patient's comments and physical performance. To minimize the contact of medical staff, including the nurses, with the patient, electrocardiography (ECG) and blood pressure monitoring were not performed.

The adherence and content of rehabilitation did not differ between remote and direct rehabilitation. However, during remote rehabilitation, patients and physiotherapists were not in the same space. Both types of rehabilitation included therapeutic muscle exercises and aerobic exercises. In direct rehabilitation, ADL exercises were sometimes included depending on the patient's activity levels. Patients occasionally needed the one-on-one assistance of physiotherapists with full PPE. If the physical ability of patients undergoing direct rehabilitation improved so that they met the criteria for remote rehabilitation, they were transferred to remote rehabilitation.

Rehabilitation therapy was started as soon as the patient's general condition (considering oxygen supply and SpO<sub>2</sub>, among others) permitted. Patients were excluded if their condition met any of the cancellation criteria or if the patient refused rehabilitation. The cancellation criteria were those given in the Guidelines for Safety Management and Promotion by the clinical practice guidelines committee of the Japanese Association of Rehabilitation Medicine.<sup>13,14)</sup>

Each rehabilitation session lasted for approximately 20 min for remote rehabilitation. For direct rehabilitation of patients with decreased ADLs, two or more daily sessions were sometimes necessary because physiotherapists had to raise patients and keep them sitting on the bedside for some time with full assistance or in a wheelchair with full assistance transfer to improve muscle resistance.

Rehabilitation was continued in the isolation area until the patient was discharged. Some patients were directly discharged from the COVID-19 isolation wards when they

recovered from COVID-19 symptoms and required no specific further medical care regardless of the necessity for rehabilitation (i.e., if they could walk independently or perform basic ADLs). Patients whose SARS-CoV-2 PCR test results were negative were allowed to be discharged, and those whose SARS-CoV-2 PCR test results were positive were recommended to stay at the COVID-19 isolation hotel, as mandated by the Tokyo administration. Those who could not walk stably or could not perform basic ADLs compared with their pre-infection abilities at that point were transferred to a rehabilitation hospital. Some patients were returned to the hospitals to which they were previously admitted if their condition did not worsen and if special medical care such as antiviral medications and steroid treatment were no longer necessary. Similar to the treatment for other lung conditions, only light medical care, including interventions for the side effects of medications, is provided in general hospitals for patients with COVID-19.

## Patients

To effectively evaluate the characteristics of rehabilitation for patients with COVID-19, we included the data of all consecutive patients with COVID-19 admitted to our hospital who underwent rehabilitation in the general and ICU COVID-19 wards between April 21 and August 20, 2020. We examined the number of patients with COVID-19 who were admitted to our hospital and the number of patients who underwent rehabilitation. We also investigated the number of patients who were transferred to or from the ICU during rehabilitation. We analyzed the age, sex, PCR test results at the initiation of rehabilitation, the day of rehabilitation initiation post admission, the duration of the ward stay, the total number of rehabilitation patients and sessions, the number of direct rehabilitation sessions performed with full PPE, and the number of daily sessions performed by each physiotherapist with or without PPE. For patients transferred between the general ward and the ICU, the duration of stay in each ward, the duration of rehabilitation days, the total number of patients, and the total number of sessions were counted separately. Data concerning the PCR results of those patients who started rehabilitation in the ICU and were transferred to the general ward were evaluated in the ICU and were not duplicated.

## Statistical Analyses

Patients were divided into the rehabilitation group and the non-rehabilitation group. The chi-squared test was used to compare categorical variables between the groups, and

**Table 1.** The characteristics of patients with COVID-19

Characteristics	Total	Rehabilitation (+)	Rehabilitation (-)	P
Patients (n)	161	95	66	
Admission to ICU (n)	47	17	30	<0.001 <sup>b*</sup>
Admission to a general ward (n)	114	78	36	
Men/women (n)	110/51	66/29	44/22	0.8381 <sup>b</sup>
Age (years), median (range)	53.5 (20–96)	59.1 (20–96)	45.5 (20–88)	<0.001 <sup>a*</sup>
ECMO (n)	4	3	1	
Intubation (n)	17	17	0	

<sup>a</sup>Mann–Whitney test to compare the ages of patients between the rehabilitation group and non-rehabilitation group.

<sup>b</sup>Chi-squared test to compare the sex of patients between the rehabilitation group and non-rehabilitation group.

\*Significantly different between the two groups.

the Mann–Whitney U test was used to compare numeric variables between the groups. Patients in the rehabilitation group were again divided into the ICU group and the general ward group. The Mann–Whitney U test was used to compare numeric variables and the number of daily sessions per patient between the groups. The Kolmogorov–Smirnov test was used to assess the assumption of normal distribution and homogeneity of variance between the two groups before the Mann–Whitney U test was performed. All statistical analyses were performed using Bell Curve for Excel 2016 (Social Survey Research Information, Tokyo, Japan). Statistical significance was set at  $P < 0.05$ .

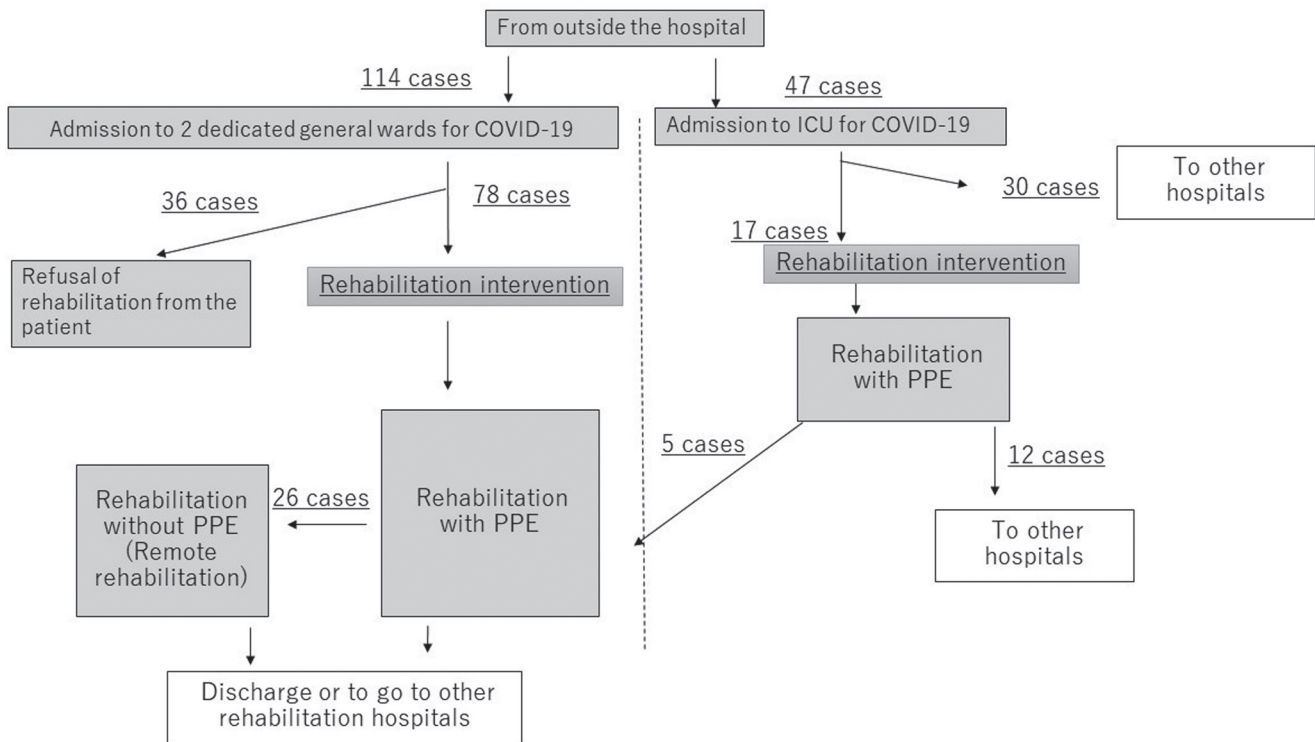
### Ethical Considerations

This study was approved by the research ethics committee of the Tokyo Medical and Dental University (M2018-073) and was conducted in accordance with the World Medical Association Declaration of Helsinki. No patient showed impaired decision-making capacity at the time of admission; however, patients identified a family member to provide consent on their behalf. Written consent from patients with COVID-19 was not directly obtained because of the risk of virus transmission. Written informed consent was obtained by mail from the family member whom the patient selected as their key person or guardian (conservator) because visitors were forbidden from entering the hospital during the pandemic. In Japan, digital signatures are not considered legally binding.

## RESULTS

A total of 161 patients with COVID-19 (110 men, 51 women) were admitted between April 21 and August 20, 2020, among which 114 patients with moderate COVID-19 were in

the general wards, and 47 with severe COVID-19 were in the ICU. Two patients were transferred from the general ward to the ICU because of exacerbation of symptoms before the initiation of rehabilitation intervention. These two patients died before rehabilitation intervention in the ICU could be initiated. Of the 161 patients, 95 underwent rehabilitation therapy, of these, 78 patients with moderate COVID-19 were in the general wards, whereas 17 patients with severe COVID-19 were in the ICU (**Table 1**). Eleven patients were transferred to the COVID-19 general ward after being discharged from the ICU. No patient experienced exacerbation of symptoms after the initiation of rehabilitation interventions in the COVID-19 general wards. The non-rehabilitation group consisted of 36 young patients who refused rehabilitation with a physiotherapist because they were not experiencing physical inconvenience, and 30 patients transferred early to their previous hospitals after extubation in the ICU (**Fig. 2**). A larger proportion of patients with COVID-19 in the general wards underwent rehabilitation than did those in the ICU. The patients in the rehabilitation groups were significantly older than those in the non-rehabilitation groups ( $P < 0.001$ ). The proportion of the sexes was not significantly different between these two groups ( $P < 0.8381$ ). Rehabilitation started significantly earlier in the COVID-19 general wards ( $P = 0.003$ ), where a significantly higher rate of positive PCR test results for SARS-CoV-2 was also found ( $P = 0.009$ ). We initiated rehabilitation as soon as possible in the COVID-19 general wards, regardless of the patients' PCR test results. In the COVID-19 ICU, rehabilitation started after the patients recovered from deep sedation. Overall, 83.2% of patients tested positive for SARS-CoV-2 at the start of rehabilitation. PCR testing for SARS-CoV-2 was done regularly during hospitalization, and the patients were kept in dedicated COVID-19 wards until discharge, even if their PCR test result



**Fig. 2.** Flow chart of the selection of patients with coronavirus disease (COVID-19) undergoing rehabilitation.

for SARS-CoV-2 became negative during their hospital stay. Doctors and physiotherapists had to wear full sets of PPE in the red zone, even when rehabilitating patients who were in the COVID-19 ward with negative PCR test results.

The durations of stay in the ICU and general wards were not significantly different ( $P=0.557$ ). However, the number of days on which patients underwent rehabilitation interventions was significantly higher in the COVID-19 general wards ( $P=0.022$ ) (Table 2) than in the COVID-19 ICU.

In total, 1035 sessions of rehabilitation therapy were performed by the 95 patients who underwent rehabilitation: 882 sessions by patients with moderate COVID-19 in the general wards and 153 sessions by patients with severe COVID-19 in the ICU. The mean number of daily sessions performed by each patient was 1.9 and 1.3 in the ICU and the general wards, respectively. The number of daily sessions for each patient in the ICU was significantly higher than those in the general wards ( $P<0.001$ ).

Among the 1035 rehabilitation sessions performed, 86 sessions were supervised remotely. Among 78 patients with COVID-19 who performed rehabilitation in general wards, 24 were switched to remote rehabilitation. With remote rehabilitation, physiotherapists did not need to wear PPE because they were in the green area; consequently, the time

physiotherapists spent in the red zone was reduced.

The mean number of rehabilitation sessions performed by one physiotherapist was 4.6 sessions per day, among which 0.3 were remote rehabilitation. The mean number of sessions performed daily while wearing full sets of PPE was 4.3. Of the 95 patients who underwent rehabilitation, PCR test results for SARS-CoV-2 were positive in 79 patients at the initiation of rehabilitation.

There were no serious adverse events, such as deep venous thromboses, pulmonary emboli, arrhythmias, hyper- or hypotension, or falls in any of the rehabilitation groups during the study period. No hospital-acquired infections occurred during this period among the medical staff involved in the study, including the doctors, nurses, and physiotherapists.

## DISCUSSION

Information about rehabilitation therapy for patients with COVID-19 is lacking.<sup>1)</sup> Our previous report revealed the effectiveness of both direct and remote rehabilitation in patients with COVID-19.<sup>12)</sup> In the current study, we investigated the characteristics and efficiency of rehabilitation therapy in patients with SARS-CoV-2 infection. We found that 59.0% of the patients admitted to our hospital with CO-

**Table 2.** Characteristics of rehabilitation sessions in COVID-19 general wards and the ICU

	Total	General wards			ICU			P
		Total	Direct rehabilitation (with PPE)	Switched to remote rehabilitation (without PPE)	Total	Direct rehabilitation (with PPE)	Remote rehabilitation (without PPE)	
Patients (n)	95	78	78	26	17	17	0	
PCR positive at rehabilitation initiation (n)	79		69			10		0.009 <sup>b*</sup>
Rehabilitation initiation (day [range])	4 (2–40)		3 (2–26)			9 (2–40)		0.003 <sup>a*</sup>
Ward stay (days [range])**	13 (3–113)		13 (3–113)			15 (3–39)		0.557 <sup>a</sup>
Rehabilitation duration (days [range])**	4 (1–63)		5 (1–63)			2 (1–21)		0.022 <sup>a*</sup>
Total sessions (n)**	1035	882	796	86	153	153	0	
Total sessions per patient (n [range])**	11 (1–101)		11.3 (1–101)			9 (1–45)		0.079 <sup>a</sup>
Daily sessions per patient (n [range])**	1.3 (1–3)	1.3 (1–2)	1.3 (1–2)	1 (all 1)	1.9 (1–3)	1.9 (1–3)	0	<0.001 <sup>a*</sup>
Daily sessions per physiotherapist (n)**	4.6	3.4	3.1	0.3	1.2	1.2	0.0	

<sup>a</sup>Mann–Whitney test to compare the age of patients in the general wards and the ICU.

<sup>b</sup>Chi-squared test to compare the sex of patients in the general wards and the ICU.

\*Significantly different between the two groups.

\*\*In cases of transferred patients, data were handled separately, i.e., data were attributed to either the ICU or general ward.

COVID-19 underwent rehabilitation therapy, and the patients in the rehabilitation group were significantly older than those in the non-rehabilitation group. Patients in the ICU were deeply sedated for respiratory control, and prone therapy was sometimes performed for patients with COVID-19 and acute respiratory distress syndrome.<sup>15)</sup> During this time, if active rehabilitation by physiotherapists could not be performed, nurses assisted the patients with position drainage and ROM exercises.

Once rehabilitation was started, a significantly higher number of sessions were performed per day by patients in the COVID-19 ICU than in the COVID-19 general ward. Early mobilization in the ICU entailed a longer duration with physiotherapists in full PPE. Moreover, early mobilization required more than two sessions with two physiotherapists because patients had developed muscle weakness and were attached to many types of equipment.

In the COVID-19 general wards, 9.8% of the rehabilitation consisted of remote rehabilitation and thereby reduced the

need for direct rehabilitation with the medical staff wearing full sets of PPE. Nonetheless, 90.2% of rehabilitation was performed with full PPE. Remote rehabilitation significantly minimized the contact with patients and the use of PPE.

For COVID-19 rehabilitation, risk management is especially important. In the COVID-19 wards, doctors or nurses did not always remain in the red zone. If consultation or treatment of vital changes was required, medical staff had to don PPE before entering the red zone from the green zone. Consequently, strict risk management was necessary for patients receiving COVID-19 rehabilitation. For remote rehabilitation, risk management is even more important because the physiotherapist was not physically present in the red zone. The patient performed the exercises on their own while the physiotherapist observed the patient from the green zone using an iPad tablet. In this scenario, falls represent severe complications to be avoided. Without the assistance of a doctor or a physiotherapist, patients face a greater risk of falls, which may cause fractures requiring prompt surgery.

It is difficult to transfer patients with COVID-19 to the clean area of the operating room because of the high risk of infection transmission and nosocomial infections. The physical ability to stand up in a controlled manner from a squatting position was one of the criteria for initiating remote rehabilitation, this ability was important because remote rehabilitation consisted of active muscle training during standing or stepping.<sup>12)</sup> Some criteria should be set depending on the patients' characteristics, consistency of remote rehabilitation, or the circumstances of monitoring with respect to risk management.

During remote rehabilitation, SpO<sub>2</sub> and heart rate were monitored remotely, and the patient's feedback on the iPad was assessed; however, ECG was not performed and blood pressure was not monitored. Remote rehabilitation was aimed at reducing the risk and duration of exposure of the medical staff, including nurses, to the infection zone. Consequently, we did not ask nurses to perform ECGs or measure blood pressure on daily initiation of rehabilitation; the monitoring of vital signs was done by reference to data recorded on the medical chart. During exercises, no vital changes were gained on monitoring during direct rehabilitation, but patients with arrhythmia, ischemic disease, or hyper- or hypotension were excluded from remote rehabilitation because these conditions could not be monitored without performing ECG. For two patients not on oxygen therapy who could stand stably, general rehabilitation was selected because of atrial fibrillation. A wearable device to monitor SpO<sub>2</sub> in the earlobe and the heart rate based on maxillomandibular bone conduction would improve monitoring during remote rehabilitation.

The proportion of PCR-positive cases at the start of rehabilitation was higher in the general ward than in the ICU. Rehabilitation initiation was later in the ICU, and PCR testing for SARS-CoV-2 of patients with COVID-19 in the ICU showed a higher proportion of negative results than that of patients in the COVID-19 general wards. This can be explained by the earlier start of rehabilitation in the COVID-19 general wards than in the ICU and the fact that the viral loads of SARS-CoV-2 in the respiratory tract decrease rapidly after the onset of symptoms.<sup>16)</sup> In the ICU, rehabilitation by physiotherapists was started after patients came out of deep sedation.

Medical staff underwent regular check-ups including PCR testing for SARS-CoV-2; however, no hospital-acquired infections were observed among doctors, physiotherapists, or other medical staff involved with rehabilitation therapy or the general treatment for PCR-positive patients during the study period. Furthermore, no serious adverse events were

noted in any of the rehabilitation patients during the study period.

Initially, to prevent nosocomial infections, we considered that therapy teams should be divided into two groups, with one group working exclusively with COVID-19 patients. If nosocomial infections occur, contacts should be traced, regardless of possible reductions in the availability of the physiotherapy and rehabilitation staff workforce. However, training on the correct way to wear PPE prevented hospital-acquired infections at our hospital, as supported by previous studies.<sup>17,18)</sup> As a result, we started managing patients with and without COVID-19 on the same day, divided into morning and afternoon sessions for efficiency. To preserve PPE supplies and for efficiency, rehabilitation for patients with COVID-19 was performed consistently in the afternoon.

As stipulated by the Japanese health insurance system, one physiotherapist can oversee as many as 20 sessions a day, and about 15 sessions a day are usually performed at our hospital. One session corresponds to 20 min of therapy. To perform rehabilitation therapy with PPE was challenging and exhausting for the medical staff because of humidity and discomfort. In our study, on average, 4.6 sessions were performed daily by one physiotherapist, and 4.3 of these sessions were performed with the physiotherapist wearing a full set of PPE. To perform 4.3 sessions would normally take around 90 min; however, in the red zone, considering the preparation time required from session to session, about a 120-min stay in the red zone was found to be necessary. The guidelines recommend allocating one additional full-time-equivalent physiotherapist per four ICU beds.<sup>5)</sup> In the current study, the mean number of sessions per day for one patient in the COVID-19 ICU was 1.9, and 4.6 daily sessions were performed by one physiotherapist, although, in the very early stages of rehabilitation, ICU nurses were involved instead of physiotherapists to carry out position drainage or passive ROM exercise. The decision to perform or not to perform rehabilitation therapy depends on the need for rehabilitation therapy, the severity of the disease, and the patient's ICU stay duration. Moreover, the physical and mental limits of doctors and physiotherapists with respect to work with PPE in the red area must also be considered.

Early rehabilitation during COVID-19 infection is necessary because some patients have acute pneumonia and may require intubation and ECMO.<sup>10,11)</sup> However, to start rehabilitation for patients who are PCR-positive for SARS-CoV-2 or patients in COVID-19 specialized wards, the wearing of full sets of PPE is necessary to prevent transmission of infection. It is important to assess the indication for rehabilitation



therapy according to the number of patients with and without SARS-CoV-2 infection, those who require rehabilitation in the hospital as a whole, the number of doctors and physiotherapists, and the available stock of PPE.

This study has several limitations. First, it was a single-center, retrospective, observational study concerning the efficacy of COVID-19 rehabilitation. A larger multicenter cohort should be studied for a longer duration to validate, from many viewpoints, the effectiveness and safety of rehabilitation for COVID-19 patients. Although relatively few patients were included in the current analysis, we believe that this study is clinically meaningful regarding the characteristics of patients with COVID-19. Our lessons on the urgent need for rehabilitation should be shared, considering the prospect of a second or third wave of SARS-CoV-2 infection. Second, COVID-19 data vary by country, region, and governmental policy, and the findings of this study may be particular to Japan or to regions with similar governmental policies.

In conclusion, we performed both direct rehabilitation therapy with PPE and remote rehabilitation therapy without PPE for patients with COVID-19. We investigated the characteristics and efficiency of rehabilitation provided in the ICU as well as for remote and direct rehabilitation provided in the general ward. In the general ward, compared with the ICU, more patients underwent rehabilitation and the number of intervention days was higher. However, in the ICU, the duration of daily sessions was significantly longer and a significantly higher number of sessions per day was performed than in the general ward. In the general ward, 9.8% of rehabilitation was performed remotely, whereas 90.2% was performed directly (wearing full PPE). An average of 4.6 rehabilitation sessions was performed daily by one physiotherapist wearing a full set of PPE, taking into consideration the physical and mental limits of doctors and physiotherapists working with PPE, although remote rehabilitation avoided the need for PPE. COVID-19 rehabilitation required additional effort because the wearing of PPE was necessary for most of the sessions and a longer rehabilitation period was needed for patients with COVID-19 in the ICU. Furthermore, the indication of rehabilitation therapy must be done taking into consideration the number of patients without SARS-CoV-2 infection who require rehabilitation and those with SARS-CoV-2 infection, the availability of doctors and physiotherapists, and the stock of PPE.

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## CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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