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Original Research

Oxygen Therapy During Activities of Daily Living Rehabilitation and Outcome in Patients With Severe-to-critical COVID-19

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KEYWORDS
ADL;
COVID-19;
Oxygen therapy;
Rehabilitation

Abstract *Objective:* To primarily study the duration of supplemental oxygen use while performing ADLs (activities of daily living) and associations leading to a more prolonged oxygen therapy during these tasks. Secondary objectives include (1) studying the presence of COVID-19 related complications during inpatient rehabilitation and after discharge and (2) describing functional outcomes of participants after supplemental oxygen liberation and hospital discharge.
Design: Explorative prospective observational cohort study.
Setting: Rehabilitation center within a tertiary hospital, caring for post-COVID patients.
Participants: Twenty-three (N=23) community-dwelling persons with severe-to-critical COVID-19 disease and ongoing oxygen therapy needs. There was a preponderance of men (69.6%), with mean age of 69.5 (range 46-85) years.
Interventions: Inpatient pulmonary rehabilitation.
Main Outcome Measures: The primary outcome was the duration of supplemental oxygen use (from initiation till wean) for ambulation, toileting, dressing, and showering. Secondary outcomes included the presence of COVID-19 related complications (during rehabilitation and after discharge) and post-discharge functional status.
Results: After rehabilitation center transfer, all subjects only required oxygen therapy during task(s) performance, and not at rest. ADLs that took the shortest and longest time for supplemental oxygen weaning were dressing (mean 38.4±SD 17.1 days) and showering (mean 47.7±SD 18.1 days), respectively. The mean duration of oxygen therapy application was 48.6±SD 18.3 days. On multivariable analysis, mechanical ventilation and exertional desaturation were significantly associated with prolonged duration for oxygen therapy in all ADLs.

List of abbreviations: 30CST, 30 seconds Chair stand test; ADL, activity of daily living; CCI, Charlson Comorbidity Index; COPD, chronic obstructive pulmonary disease; FAC, Functional Ambulation Category; ICU, intensive care unit; POS, Platypnea Orthodeoxia Syndrome.
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Conclusion: The duration of needful oxygen therapy was dissimilar for different ADLs. Showering, which required the longest duration of supplemental oxygen wean, might prove to be the rate-limiting ADL for discharge home.

COVID-19, caused by SARS-CoV-2, was first recognized in December 2019 and rapidly reached pandemic proportions in subsequent months.[1] The following years that ensued saw to the ebbs and flows of SARS-CoV-2 variants. These differed in their infectiousness, disease severity, and response to therapeutic medications/vaccines.[2-4]

COVID-19 is primarily an acute respiratory disease. With every COVID-19 wave, there exists a subpopulation with significant respiratory sequelae, presenting with hypoxia and/or dyspnea, necessitating oxygen therapy, sometimes for a protracted time. Such individuals had been defined as having severe, or critical, COVID-19 illness.[5] They were typically hospitalized, requiring oxygen supplementation and perhaps ventilatory support.[5]

Upon recovery, supplemental oxygen weaning can occur over a period, starting with oxygen use at rest. Even then, hypoxia and/or dyspnea can still persist with exertion and/or body positioning (eg, POS or Platypnea Orthodeoxia Syndrome: dyspnea and desaturation after a body position change from horizontal to vertical).[6-9] These would have great functional effect on recovering persons, affecting the most basic of self-care.[9] However, there has been a scarcity of reports on the effect of COVID-19-related oxygen dependance on ADLs (activities of daily living) tasks.

Our study followed the trajectory of 23 subjects with severe-to-critical COVID-19 respiratory disease. We aim to study the duration of supplemental oxygen use while performing ADL tasks, and the associations leading to a more prolonged oxygen therapy. We also describe the respiratory and functional outcomes of these participants in the months after supplemental oxygen liberation and hospital discharge.

Materials and methods

This explorative prospective cohort study was conducted between December 15th, 2021, and July 31st, 2022, in a rehabilitation center, within a tertiary hospital in Singapore, caring for patients post-COVID infection with ongoing oxygen therapy and rehabilitative needs. Participants recruited fulfilled the following inclusion criteria: (1) adults ≥18 years; (2) admitted to hospital with proven COVID-19 infection; (3) concurrent radiological evidence of infective lung changes (x-ray or computer tomographic); and (4) receiving supplemental oxygen at rest and/or during activities. Individuals on long-term oxygen therapy premorbidly were excluded from this study. The subjects underwent inpatient pulmonary rehabilitation with a focus on respiratory and physical conditioning (10-15 hours per week), undertaken by a multi-disciplinary team (consisting of rehabilitation medicine physicians, physiotherapists, and occupational therapists). The participants were reviewed, 2-6 months from the date of discharge, for assessments of their functional ability.

The present study was approved by the ethics committee at our institution (NHG DSRB 2021/01045). Informed consent was obtained from the eligible participants for enrolment into this study. This manuscript adheres to the applicable STROBE guidelines.

Data collection

Baseline demographic and clinical characteristics were obtained from inpatient hospital electronic hospital records. These included age, sex, ethnicity, marital status, employment, smoking, vaccination status, premorbid function, and comorbidities. Comorbidities were also represented using the Charlson Comorbidity Index (CCI),[10] a validated tool to assess comorbidity.

Details of the participants' acute hospitalization and rehabilitation stays were recorded, (including the length of stays), respiratory support instituted (including supplemental oxygen use), and functional status at discharge. Specifically, common post severe-critical COVID illness complications such as POS (defined as an orthostatic dyspnea with a drop in SpO_2 >5% or PaO2 >4 mmHg),[6,7] exertional desaturation (defined as a drop in SpO_2 by ≥4% drop in SpO_2 during exertion)[9] and postural hypotension (defined as a drop in systolic blood pressure of at least 20 mmHg and/or diastolic blood pressure of at least 10 mmHg within 3 minutes of standing)[11] were noted.

FIM,[12] an 18-item, clinician-reported scale that assesses an individual's functional capability in 6 domains (self-care, continence, mobility, transfers, communication, and cognition), was used to score the subjects' functional ability on admission and discharge from the rehabilitation center.

Discharge destinations and Functional Ambulation Category (FAC)[13] scores at discharge were also recorded. FAC, which ranges from 0 (unable to walk or requires more than 1 person to assist) to 5 (able to walk independent on any surface including stairs), is a 6-point observer-assessed score for evaluation of ambulation ability. This had been mainly used in patients with neurologic conditions (eg, stroke), but we have used it here on our subjects, some of whom presented with new-onset weakness (albeit largely non-neurologic in origin).

Participants were reviewed by rehabilitation medicine physicians between 2 and 6 months after discharge from the rehabilitation center. Details of physical and functional performance were collected, as was the return-to-employment status. Thirty seconds Chair stand test (30CST)[14] was used as a measure of lower limb strength in the assessment of

physical function during follow-up. The continued presence of limb weakness, postural hypotension, exertional desaturation, exertional dyspnea, POS, and resting oxygen saturation were recorded at these reviews.

Outcome measures

Primarily, the duration of oxygen therapy while performing the various basic ADLs were evaluated. These tasks included level ground ambulation (minimum of 10 m), dressing, toileting, and showering. The start point was considered as the day that supplemental oxygen was initiated. The first day that the subject did not require oxygen therapy, and with SpO_2 consistently kept above 92%, to complete the task was taken as the endpoint.

A secondary outcome measured was the presence and persistence of COVID-19 related complications during inpatient rehabilitation and the post discharge period (ie, between 2 and 6 months from rehabilitation center discharge), respectively. These included resting oxygen desaturation, exertional desaturation/dyspnea, POS, postural hypotension, and acquired limb weakness. In the outpatient setting, exertional desaturation and dyspnea were determined after performance of 30CST.

Another secondary outcome was to examine the return to premorbid functionality. These included the ability to perform basic ADLs, life space mobility, and return to employment. Life space mobility,[15] a concept for assessing functional mobility over time, was simply defined at 3 levels — homebound mobility, limited community mobility, and unlimited community mobility. Individuals who were only accessing facilities in the vicinity of their home (eg, convenience stores, markets) and not venturing further, were determined to have had limited community mobility. Unlimited community mobility indicated that the person was traveling beyond areas near home — usually by taking public transportation or driving.

Statistical analysis

Descriptive statistics were used to illustrate demographics and clinical characteristics. There were no missing data. T-tests and Mann-Whitney *U* tests were implemented as appropriate depending on whether analysis was performed on parametric or non-parametric data. Correlation analyses were performed betwen identified variables and the duration (days) of oxygen use. Pearson's correlation was used to determine the relations between continuous and nominal data. Spearman's correlation was used to determine relations between continuous data and ordinal data.

Variables were subjected to analysis investigating their relation with the primary outcome (ie, time taken to wean off supplemental oxygen for the various ADL tasks). These variables included age, sex, ethnicity, co-morbidities (as CCI), smoking status, vaccination status, admission to ICU (intensive care unit), mechanical ventilation, POS, exertional desaturation, postural hypotension, limb weakness, and admission FIM. Linear regression was used for multivariable analysis. A $P<.05$ was considered statistically significant for a 2-tailed test. Statistical analyses were conducted using SPSS Version 25.0.[a]

Results

Twenty-three subjects were enrolled into the study, most of whom were male and of Chinese ethnicity. Their ages ranged from 46 to 85, with most (60.9%) more than 65 years of age. All of the participants were independent in basic ADLs (including ambulation) premorbidly. Slightly more than half of the subjects were unvaccinated. Other demographic and clinical data are illustrated in tables 1 and 2, respectively.

On transfer to the rehabilitation center, the participants still required supplemental oxygen therapy, though this was only applied during performance of ADLs and/or verticalization. The average time taken for supplemental oxygen to be totally weaned off was 48.6 days. Among the basic ADLs studied (ambulation, toileting, dressing, and showering), the tasks that took the shortest and longest time for oxygen to be weaned off were dressing (38.4 days) and showering (47.7 days), respectively. The activity of showering took the longest time for supplemental oxygen weaning in 16 (69.6%) of the participants (fig 1). By discharge, all the participants had no need for supplemental oxygen use during performance of the 4 ADL tasks.

On correlation analysis, we found that admission to ICU and need for mechanical ventilation were significantly associated with prolonged duration of oxygen therapy (for all ADLs and also in totality). Limb weakness was significantly associated with an increased duration of supplemental oxygen use during showering, as well as the total duration of supplemental oxygen use in totality. However, on multivariable analysis, only the need for mechanical ventilation and presence of exertional desaturation were consistently identified as significant factors for all primary outcomes with the former being more strongly associated (table 3).

During inpatient rehabilitation, there was a significant proportion of patients with complications (fig 2). Respiratory complications, such as POS, exertional dyspnea/desaturation, were more commonplace. Although all the subjects experienced exertional dyspnea, only 20 (87.0%) were observed to have accompanying exertional desaturation. POS was observed in 19 (82.6%) of the subjects. By discharge, there were functional improvements observed in all participants, with a mean FIM score gain of 28.2. Nineteen subjects (82.6%) had achieved independent ambulation (FAC 4 & 5) but only 15 (65.2%) had achieved independence in all the basic ADLs at discharge. The median lengths of inpatient rehabilitation and hospital stays were 20.0 and 52.0 days, respectively (table 2).

During follow-up between 2 and 6 months, 2 participants did not turn up for rehabilitation follow-up as they felt well enough (ascertained via follow-up calls to the subjects when they missed their scheduled appointment). The data of the remaining 21 subjects were described. Resting SpO_2 was normalized in all the subjects (ranging from 95% to 100% on room air). Postural hypotension, exertional dyspnea, and desaturation were resolved in a significant portion of the study cohort. POS and limb weakness resolved and were no longer detected in those who attended their follow-ups (fig 2). Of the 6 participants who had persistent exertional dyspnea, 2 had accompanying exertional desaturation. Two were noted to have exertional desaturation without dyspnea. Almost all achieved independent ambulation - one was confined to wheelchair mobility because of a mishap

Table 1 Demographic characteristics of study population

Characteristics	N=23
Age, years, mean (±SD)	69.5 (10.3)
Sex, n (%)	
Male	16 (69.6)
Female	7 (30.4)
Ethnicity, n (%)	
Chinese	20 (87.0)
Malay	2 (8.7)
Indian	1 (4.3)
Marital status, n (%)	
Single	7 (30.4)
Married	15 (65.2)
Widowed	1 (4.3)
Preadmission co-morbidities, n (%)	
Hypertension	13 (56.5)
Hyperlipidemia	11 (47.8)
Diabetes mellitus	6 (26.1)
Previous myocardial infarction	4 (17.4)
Previous stroke	2 (8.7)
Chronic obstructive pulmonary disease	1 (4.3)
Charlson Comorbidity Index, n (%)	
<4	14 (60.9)
≥4	9 (39.1)
Smoking status, n (%)	
Active smoker	2 (8.7)
Ex-smoker	5 (21.7)
Non-smoker	16 (69.6)
COVID vaccination status (at time of disease contraction), n (%)	
Non-vaccinated	12 (52.2)
Partially vaccinated	4 (17.4)
Fully vaccinated	7 (30.4)
Employment premorbidly, n (%)	
Yes	7 (30.4)
No	16 (69.6)
Premorbid functional status, n (%)	
Independent in basic ADLs	23 (100.0)
Requires assistance in basic ADLs	0 (0.0)
Premorbid Functional Ambulation Category, n (%)	
0, 1, 2, & 3	0 (0.0)
4	2 (8.7)
5	21 (91.3)

Table 2 Clinical characteristics

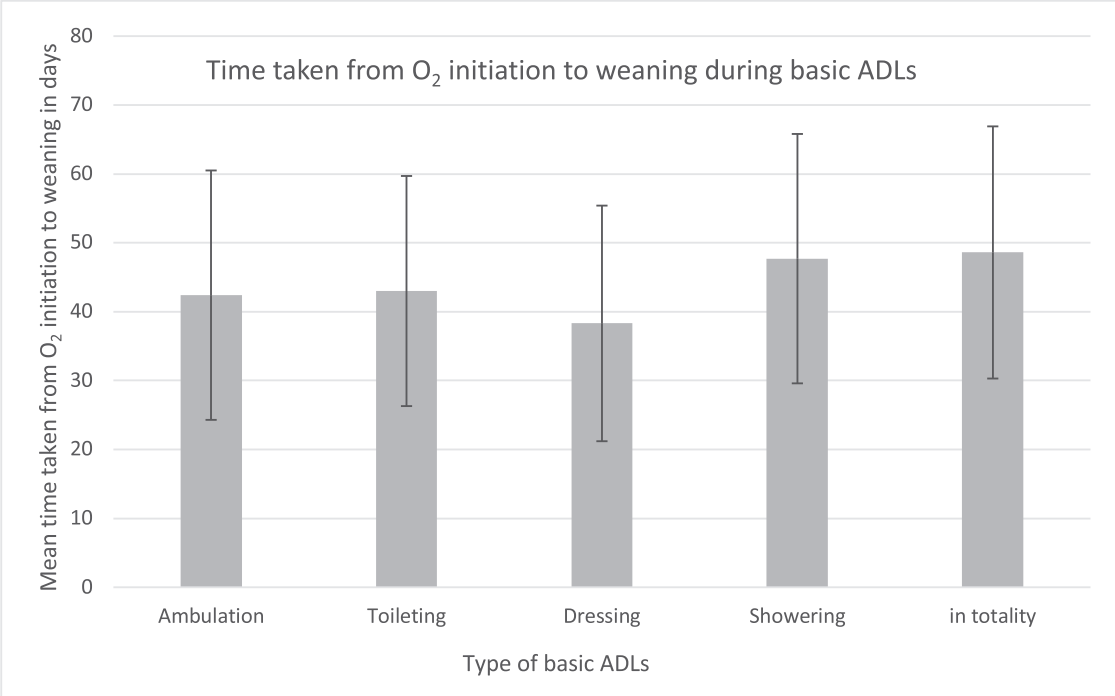
Characteristics	N=23
Length of hospital stay (days), median (interquartile range)	52.0 (38.0)
Length of rehabilitation stay (days), median (interquartile range)	20.0 (16.0)
Respiratory support during acute stay, n (%)	
Mechanical ventilation	7 (30.4)
Non-invasive ventilation	16 (69.5)
Status at discharge	
FIM score on admission to rehabilitation center, mean (±SD)	81.4 (18.1)
FIM score on discharge, median (interquartile range)	112.0 (20.0)
FIM score gain, mean (±SD)	28.2 (17.3)
Functional status at discharge, n (%)	
Independence in all basic ADL	15 (65.2)
Requires supervision for at least 1 basic ADL (but not requiring physical assistance)	7 (30.4)
Requires assistance for at least 1 basic ADL	1 (4.3)
Functional Ambulation Category at discharge, n (%)	
0, 1	0 (0)
2	1 (4.3)
3	3 (13.0)
4	6 (26.1)
5	13 (56.5)
Discharge destination, n (%)	
Home	23 (100.0)
Institutional care and others	0 (0.0)

post-discharge that resulted in a hip fracture. This subject was homebound, whereas the other participants had achieved success in limited (33.3%) and unlimited (61.9%) community mobility. The mean 30CST was 11.6 repetitions in the 20 patients that were tested (2 was lost to follow-up and 1 was unable to perform due to recovering hip fracture). Of the 7 subjects who held employment premorbidly, only 3 (42.9%) returned to work (table 4).

Discussion

Arterial hypoxemia in COVID-19 disease occurs owing to a possible myriad of mechanisms such as impaired diffusion capacity, altered pulmonary perfusion, formation of microthrombi, and/or an intrapulmonary shunt.[16] Increased oxygen requirement had been reported as high as 65% of COVID-19 survivors.[17] With recovery, this hypoxemia may not manifest at rest, but gets triggered by exertion (eg, performing ADLs). This is clinically identifiable by a decrease in oxygen saturation and may be accompanied by fatigue and dyspnea. As a result, performance of such activities can be negatively affected.[9]

Application of supplemental oxygen during such tasks can help enhance performance. With further recovery, weaning of supplemental oxygen may be possible. This strategy had been adopted to assist us in training our patients with needful use of supplemental oxygen during tasks.



ADL, Activity of Daily Living; O2, oxygen

	Ambulation	Toileting	Dressing	Showering	In totality
Mean (days)	42.4	44.0	38.3	47.7	48.6
Standard Deviation	18.1	16.7	17.1	18.1	18.3

Fig 1 Time taken from oxygen (O_2) initiation to weaning during basic ADLs.

In doing so, our study found the average duration of oxygen therapy was 48.6 days. The longest documented duration of oxygen therapy was for showering and occurred at day 93 of supplemental oxygen use. Of the 4 basic ADLs observed, dressing, ambulation (short-distanced level ground), toileting, and showering, were in ascending order of time taken for supplemental oxygen to be weaned off during the respective task performance (fig 1).

A previous study involving subjects with chronic obstructive pulmonary disease (COPD) observed that the act of bathing was 1 of the top few activities that had the greatest ventilatory and oxygen consumption.[18] This was consistent with another study which postulated that activities associated with upper and lower limb movements necessitated higher ventilatory and oxygen consumption.[19] In the context of bathing/showering, increased humidification (increased water vapor) in an enclosed space reduces partial oxygen pressure and can further exacerbate desaturation and dyspnea. This could have made the task more challenging and further increased the duration of oxygen weaning.[20]

In these previous studies,[18,19] although dressing tasks rank high on the list of activities with enhanced ventilatory and oxygen consumption, dressing in our study, was the earliest activity that got weaned off oxygen supplementation. This may be due to this task being assessed and trained in a seated position in our context, thus obviating the need for concurrent upper and lower limb movement.

Although mechanical ventilation and ICU admission were associated with an increased duration for oxygen therapy in dressing, ambulation, toileting, and showering (table 3) on correlation analysis, only the former emerged as the most significant factor on multivariable analysis. This is likely indicative of COVID-19 pneumonia severity. Such survivors might have more severe and persisting pulmonary lesions (eg, fibrosis), which could account for the loss of lung function and arterial hypoxemia (clinically observed as reduced oxygen saturation) at rest or with exertion.[21] The increased time needed for activity adaptation and resolution of exertional desaturation were observed as a lengthened duration for supplemental oxygen weaning during these different tasks.

We noted that in our cohort, inpatient rehabilitation occupied slightly more than a third (38%) of the subjects' total hospitalization. The time taken would be for a combination of physical as well as early respiratory rehabilitation. Pulmonary rehabilitation had been asserted to assist with enhancing oxygen extraction, improving exercise tolerance and ventilatory efficiency in studies involving COPD patients.[22] We posit that rehabilitation had been helpful in improving the functional outcome of our subjects as well. At

Table 3 Associations between participation/clinical characteristics and time taken to wean off supplemental oxygen during ADLs

Variables	Duration From Supplemental Oxygen Initiation Till Weaning During ADL				Total Duration of Oxygen Therapy
	Ambulation	Dressing	Toileting	Showering	
	Correlation Analysis Correlation Coefficient (*P* Value)				
Patient Factors					
Age, years	−0.057 (.798)	−0.106 (.630)	0.032 (.886)	0.075 (.735)	0.028 (.900)
Sex	−0.261 (.230)	−0.257 (.237)	−0.363 (.089)	−0.223 (.305)	−0.249 (.252)
Ethnicity	0.322 (.100)	0.338 (.115)	−0.409 (.037)	−0.361 (.163)	−0.360 (.143)
CCI (<4 vs ≥4)	0.020 (.927)	−0.168 (.443)	0.101 (.647)	0.054 (.807)	0.076 (.737)
Smoking status	−0.076 (.730)	0.036 (.869)	−0.135 (.540)	−0.011 (.959)	−0.067 (.761)
Vaccination status (non-/partial vs full vaccination)	−0.282 (.193)	−0.387 (.068)	−0.230 (.292)	−0.298 (.167)	−0.296 (.170)
Clinical factors					
Admission to ICU	0.534 (.009)	0.475 (.022)	0.453 (.030)	0.454 (.030)	0.462 (.027)
Mechanically ventilated	0.739 (.000)	0.778 (.000)	0.713 (.000)	0.732 (.000)	0.746 (.000)
POS	0.412 (.050)	0.312 (.148)	0.413 (.050)	0.368 (.084)	0.386 (.069)
Exertional desaturation	0.403 (.057)	0.286 (.186)	0.355 (.097)	0.336 (.117)	0.351 (.100)
Postural hypotension	0.210 (.348)	0.053 (.814)	0.126 (.577)	0.150 (.506)	0.171 (.446)
Limb weakness (≥1 limb)	0.252 (.245)	0.307 (.154)	0.410 (.052)	0.492 (.017)	0.453 (.030)
Admission FIM	−0.058 (.793)	−0.087 (.692)	−0.293 (.175)	−0.231 (.289)	−0.204 (.351)

Variables	**Duration From Supplemental Oxygen Initiation Till Weaning During Ambulation** Multivariate Analysis Standardized Coefficient B	95% CI	*P* Value
Admission to ICU	0.147	−4.579 to 16.409	.251
Mechanically Ventilated	0.831	21.919 to 41.953	.000
Vaccination status	0.510	4.808 to 34.375	.012
CCI	−0.338	−23.36 to -1.083	.033
Exertional Desaturation	0.595	15.320 to -47.192	.001

Variables	**Duration From Supplemental Oxygen Initiation Till Weaning During Dressing** Multivariate Analysis Standardized Coefficient B	95% CI	*P* Value
Admission to ICU	0.050	−12.098 to 16.123	.767
Mechanically ventilated	0.773	16.290 to 43.228	.000
Vaccination status	0.200	−12.178 to 27.580	.425
CCI	−0.080	−17.880 to 12.087	.688
Exertional desaturation	0.437	1.535 to 44.392	.037

(*continued*)

Table 3 (*Continued*)

Variables	Duration From Supplemental Oxygen Initiation Till Weaning During ADL				Total Duration of Oxygen Therapy
	Ambulation	Dressing	Toileting	Showering	
	Correlation Analysis Correlation Coefficient (*P* Value)				
Variables	**Duration From Supplemental Oxygen Initiation Till Weaning During Toileting** Multivariate Analysis				
	Standardized Coefficient B		95% CI		*P* Value
Admission to ICU	0.050		−10.613 to 14.340		.756
Mechanically ventilated	0.809		16.830 to 40.648		.000
Vaccination status	0.404		−3.236 to 31.917		.103
CCI	−0.170		−18.953 to 7.544		.376
Exertional desaturation	0.556		8.008 to 45.901		.008
Variables	**Duration From Supplemental Initiation Till Weaning During Showering** Multivariate Analysis				
	Standardized Coefficient B		95% CI		*P* Value
Admission to ICU	0.050		−12.098 to 16.123		.767
Mechanically ventilated	0.773		16.290 to 43.228		.000
Vaccination status	0.200		−12.178 to 27.580		.425
CCI	−0.080		−17.880 to 12.087		.688
Exertional desaturation	0.437		1.535 to 44.392		.037
Variables	**Total Duration of Oxygen Therapy** Multivariate Analysis				
	Standardized Coefficient B		95% CI		*P* Value
Admission to ICU	0.046		−11.515 to 15.286		.770
Mechanically ventilated	0.804		18.555 to 44.137		.000
Vaccination status	0.251		−9.081 to 28.676		.289
CCI	−0.110		−18.291 to 10.168		.555
Exertional desaturation	0.477		5.084 to 45.783		.017

P<.05 was considered statistically significant.

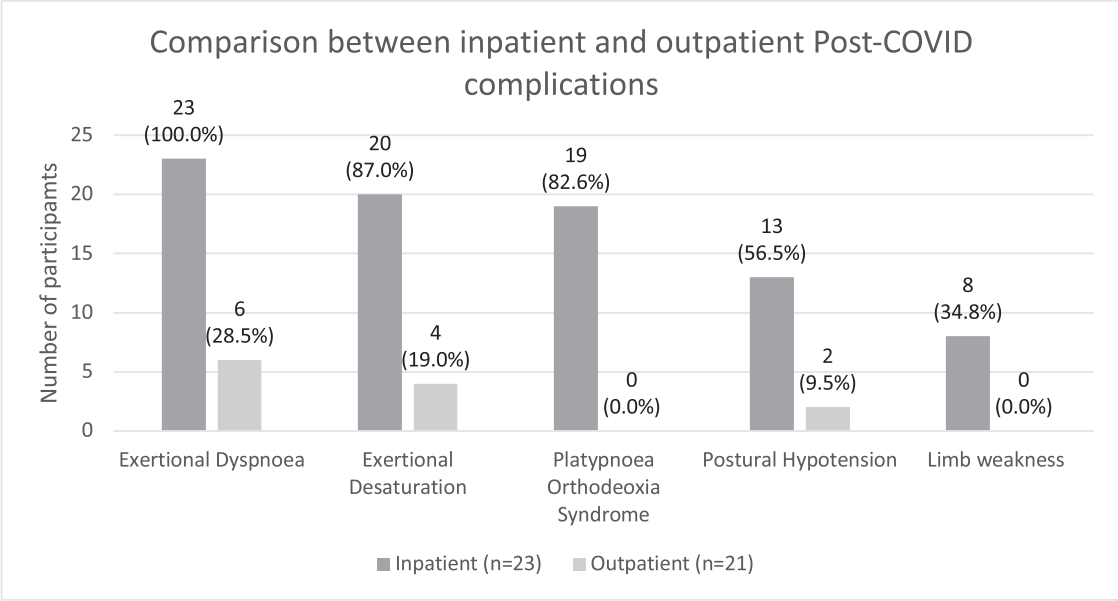


Fig 2 Comparison between inpatient and outpatient post-COVID complications. In the outpatient phase, 2 participants were lost to follow-up and hence percentages were calculated among the 21 remaining.

Table 4 Functional outcomes after discharge

Characteristics	N=21*
Ongoing Outpatient Therapy (Physiotherapy and/or occupational therapy), n (%)	3 (14.3)
Ambulation status at 2-6 months, n (%)	
Independent ambulation without aid	16 (76.2)
Independent ambulation with aid	4 (19.0)
Wheelchair mobilization	1 (4.8)
Life-space mobility, n (%)	
Homebound	1 (4.8)
Limited community	7 (33.3)
Unlimited community	13 (61.9)
Resting SpO_2 (%), Mean (±SD)	98.1 (1.3)
Presence of POS, n (%)	0 (0)
Presence of exertion dyspnea, n (%)	6 (28.5)
Presence of exertional desaturation, n (%)	4 (19.0)
Presence of postural hypotension, n (%)	2 (9.5)
30s Chair-Stand-Test† (30CST), Mean (±SD)	11.6 (3.3)
No. of patients achieving age-appropriate range of 30CST†, n (%)	1 (5.0)†
Return to employment after discharge, n (%)	3 (14.3)

* Missing data: 2 subjects did not attend follow-up after discharge and so outpatient data were unavailable.

† One patient was unable to perform CST because of a recovering hip fracture and was not included.

discharge, most (65.2%) had achieved independence in basic ADLs, freed of supplemental oxygen use.

At follow-up, 18 subjects (of the 19 that manifested POS while inpatient) had resolution of POS (1 was lost to follow-up and this could not be ascertained). Of the 20 subjects with exertional desaturation during inpatient, only 4 had demonstratable exertional desaturation on follow-up (one was lost to follow-up and this could not be ascertained). Interestingly, 2 of these 4 patients had desaturation without concomitant dyspnea ("happy hypoxics").[16] Fortuitously, the SpO_2 nadirs still kept above 92% and could quickly recover with rest and/or respiratory maneuvers. Most of the subjects had 30CST scores that were still below age norms (surveyed among local community-dwelling older adults),[23] indicating the persistence of a deconditioned physical state. Although 3 of our subjects were out of the age range in the normative data referenced,[23] they fared worse in their 30CST performance than the youngest band norms described.

These findings of incomplete recovery of physical and respiratory function could explain the restricted life space mobility in more than a third (38.0%) of the subjects, despite the fact that 95.2% of them had achieved independence in ambulation.

Limitations

There are several limitations in our study. Firstly, this study had a relatively small sample size and this may prevent extrapolation of our findings. This would also affect the strength of our findings of associations. Secondly, assessments for all the ADLs could not be performed daily, particularly over the weekends when therapy services were unavailable. Other than ambulation, which was performed on a daily basis on weekdays, the other tasks may be assessed 2-3 days apart. This may lead to over assessments on the days needed to wean off oxygen for given tasks. Thirdly, because of manpower and resource constraints at follow-ups, we did not use other functional measures of impairment such as the 6-minute walk test, which could more accurately assess physical endurance of our participants and possibly elicit exertional desaturation if present. This might have led to our study under-detecting the persistence of exertional desaturation at follow-up.

Clinical implications

In the hospital, weaning of supplemental oxygen in totality may take up to 3 months for basic self-care tasks, though the wean of supplemental oxygen to room air at rest may occur much sooner. Showering is the most challenging basic ADL task in this respect.

Given the postulated mechanisms behind prolonged oxygen therapy during showering, several adjustments can help enhance performance and hasten supplemental oxygen weaning. While respiratory maneuvers can assist with pulmonary ventilation and gaseous exchange, energy conservation strategies (eg, activity pacing, performing tasks in a seated position) can further help by reducing the metabolic and ventilatory requirements of the activity. Additionally, environmental adjustments, such as adding a ventilator fan or opening a door/window in the shower area, would reduce the build-up of humidity in this enclosed space and could improve oxygenation.

A good majority of the respiratory symptoms that occurred acutely resolved 2-6 months after discharge. Despite significant improvements in respiratory function, full return to functional baseline may not be achieved in a significant proportion of this population months after recovery. These patients may continue to have residual respiratory and physical impairments, which will require continued surveillance and support.

Conclusions

The present findings revealed that the time required for supplemental oxygen weaning was dissimilar with different ADL tasks in patients with recovering severe-to-critical COVID-19 lung disease. The most challenging of which was showering. This may prove to be the barrier to gaining full independence in self-care and should be duly considered and assessed prior to home discharge.

In our pool of subjects with severe-to-critical COVID-19 lung disease, despite the high incidence of respiratory symptoms occurring acutely, most resolved with time. Within a year of COVID disease, it was notable that resting SpO_2 readings were back within normative range. Exertional desaturation, even when persisting, still had nadirs above 92%. Nevertheless, recovery to premorbid condition at 2-6 months was not observed in most of our subjects, as evidenced by a significant proportion with below-norm 30CST scores and a third having limitations in life-space mobility.

Suppliers

a. SPSS Version 25.0; IBM Corp

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References

1. Sadeghi Dousari A, Taati Moghadam M, Satarzadeh N. COVID-19 (Coronavirus Disease 2019): a new coronavirus disease. Infect Drug Resist 2020;13:2819–28.
2. Whitaker M, Elliott J, Bodinier B, et al. Variant-specific symptoms of COVID-19 in a study of 1,542,510 adults in England. Nat Commun 2022;13:6856.
3. Aleem A, Akbar Samad AB, Vaqar S. Emerging variants of SARS-CoV-2 and novel therapeutics against Coronavirus (COVID-19) [Updated 2023 May 8], In: S*tatPearls [Internet]*, 2023, StatPearls Publishing; Treasure Island (FL). https://www.ncbi.nlm.nih.gov/books/NBK570580/. Accessed June 12, 2023.
4. Carabelli AM, Peacock TP, Thorne LG, et al. SARS-CoV-2 variant biology: immune escape, transmission and fitness. Nat Rev Microbiol 2023;21:162–77.
5. National Institutes of Health. COVID-19 Treatment Guidelines — Clinical Spectrum of SARS-CoV-2 Infection. Available at: https://www.covid19treatmentguidelines.nih.gov/overview/clinical-spectrum/. Accessed 12/6/2023.
6. Tan GP, Ho S, Fan BE, et al. Reversible platypnea-orthodeoxia in COVID-19 acute respiratory distress syndrome survivors. Respir Physiol Neurobiol 2020;282:103515.
7. Tham SL, Ong PL, Lee AJY, Tay MRJ. Rehabilitation of patients with Platypnea-Orthodeoxia Syndrome in COVID-19 pneumonia: two case reports. J Rehabil Med Clin Commun 2020;3:1000044.
8. Cortés-Telles A, López-Romero S, Figueroa-Hurtado E, et al. Pulmonary function and functional capacity in COVID-19 survivors with persistent dyspnoea. Respir Physiol Neurobiol 2021;288:103644.
9. Petilli Zopelari LM, Viana DR, Carvalho da Silva MM, Facio CA, Arcuri JF, Pires Di Lorenzo VA. Oxygen desaturation and persistence of symptoms during activities of daily living in patients following hospital discharge for COVID-19. Respir Care 2023;68:346–55.
10. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40:373–83.
11. Kaufmann H. Consensus statement on the definition of orthostatic hypotension, pure autonomic failure and multiple system atrophy. Clin Auton Res 1996;6:125–6.
12. Hamilton BB, Granger CV, Sherwin FS, Zielezny M, Tashman JS. A uniform National Data System for medical rehabilitation. In: Fuhrer M, ed. Rehabilitation outcomes: analysis and measurement, Baltimore (MD): Paul H. Brookes; 1987:137–50.
13. Mehrholz J, Wagner K, Rutte K, Meiner D, Pohl M. Predictive validity and responsiveness of the Functional Ambulation Category in hemiparetic patients after stroke. Arch Phys Med Rehabil 2007;88:1314–9.
14. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. Res Q Exerc Sport 1999;70:113–9.
15. Perracini MR, de Amorim JSC, Lima CA, et al. REMOBILIZE Research Network (CANSORT-SCI). Impact of COVID-19 pandemic on life-space mobility of older adults living in Brazil: REMOBILIZE study. Front Public Health 2021;9:643640.
16. Dhont S, Derom E, Van Braeckel E, Depuydt P, Lambrecht BN. The pathophysiology of 'happy' hypoxemia in COVID-19. Respir Res 2020;21:198.
17. Groff D, Sun A, Ssentongo AE, et al. Short-term and long-term rates of postacute sequelae of SARS-CoV-2 infection: a systematic review. JAMA Netw Open 2021;4:e2128568.
18. Kim C, Seo JB, Lee SM, et al. Exertional desaturation as a predictor of rapid lung function decline in COPD. Respiration 2013;86:109–16.

19. Vaes AW, Wouters EFM, Franssen FME, et al. Task-related oxygen uptake during domestic activities of daily life in patients with COPD and healthy elderly subjects. Chest 2011;140:970–9.
20. Ortiz-Prado E, Dunn JF, Vasconez J, Castillo D, Viscor G. Partial pressure of oxygen in the human body: a general review. Am J Blood Res 2019;9:1–14.
21. Wang F, Kream RM, Stefano GB. Long-term respiratory and neurological sequelae of COVID-19. Med Sci Monit 2020;26:e928996.
22. Miyazaki A, Miki K, Maekura R, et al. Increased oxygen extraction by pulmonary rehabilitation improves exercise tolerance and ventilatory efficiency in advanced chronic obstructive pulmonary disease. J Clin Med 2022;11:963.
23. Yee XS, Ng YS, Allen JC, et al. Performance on sit-to-stand tests in relation to measures of functional fitness and sarcopenia diagnosis in community-dwelling older adults. Eur Rev Aging Phys Act 2021;18:1.