The Stanford Hall consensus statement for post-COVID-19 rehabilitation

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ABSTRACT

The highly infectious and pathogenic novel coronavirus (CoV), severe acute respiratory syndrome (SARS)-CoV-2, has emerged causing a global pandemic. Although COVID-19 predominantly affects the respiratory system, evidence indicates a multisystem disease which is frequently severe and often results in death. Long-term sequelae of COVID-19 are unknown, but evidence from previous CoV outbreaks demonstrates impaired pulmonary and physical function, reduced quality of life and emotional distress. Many COVID-19 survivors who require critical care may develop psychological, physical and cognitive impairments. There is a clear need for guidance on the rehabilitation of COVID-19 survivors. This consensus statement was developed by an expert panel in the fields of rehabilitation, sport and exercise medicine (SEM), rheumatology, psychiatry, general practice, psychology and specialist pain, working at the Defence Medical Rehabilitation Centre, Stanford Hall, UK. Seven teams appraised evidence for the following domains relating to COVID-19 rehabilitation requirements: pulmonary, cardiac, SEM, psychological, musculoskeletal, neurorehabilitation and general medical. A chair combined recommendations generated within teams. A writing committee prepared the consensus statement in accordance with the appraisal of guidelines research and evaluation criteria, grading all recommendations with levels of evidence. Authors scored their level of agreement with each recommendation on a scale of 0–10. Substantial agreement (range 7.5–10) was reached for 36 recommendations following a chaired agreement meeting that was attended by all authors. This consensus statement provides an overarching framework assimilating evidence and likely requirements of multidisciplinary rehabilitation post COVID-19 illness, for a target population of active individuals, including military personnel and athletes.

BACKGROUND

In late 2019 a highly pathogenic novel coronavirus (CoV), severe acute respiratory syndrome (SARS)-CoV-2, emerged, causing a global pandemic with millions of cases worldwide.[1] CoVs are large enveloped non-segmented positive sense RNA viruses causing enteric and respiratory disease in animals and humans.[2] SARS-CoV-2 belongs to the CoV β-species, mainly transmitted through respiratory droplets and close personal contact, of which there have been two global epidemics in the last 20 years, SARS in 2003, caused by SARS-CoV-1, and Middle Eastern respiratory syndrome (MERS) in 2012, caused by MERS-CoV. SARS-CoV-2 causes COVID-19, which has a predilection for the lungs, and can result in a severe pneumonia, inducing serous fluid, fibrin exudates and hyaline membrane formation in the alveoli, associated with intensive care unit (ICU) admission and high mortality.[3] The complications include those meeting diagnostic criteria for acute respiratory distress syndrome (ARDS), anaemia, cardiac injury and secondary infection.[3] SARS-CoV-2, like SARS-CoV-1, enters human cells via the same receptor, angiotensin-converting enzyme 2 (ACE2).[2]

COVID-19 is a highly infectious respiratory disease and as a result, the COVID-19 pandemic has profoundly impacted the UK population resulting in strict measures to curtail spread of infection. This zoonotic disease was unknown in humans and most research has concentrated on the acute phase to reduce mortality. Acute treatment is largely symptomatic and supportive depending on the severity of infection. As of April 2020, there was no specific treatment or vaccination available. The disease is currently predicted to result in significant morbidity for 3–6 months (intermediate phase) with pressure on routine medical and rehabilitation services for 12 months and beyond (chronic phase).

The illness severity pattern so far observed is as follows;

1. Asymptomatic infected patients.
2. Symptomatic patients isolating at home.
3. Symptomatic patients admitted to hospital
4. Symptomatic patients requiring ventilatory support in critical care.

COVID-19 is a multisystem disease, which in certain cases will require full multidisciplinary team (MDT) rehabilitation to enable recovery. Whenever possible rehabilitation should commence in the critical care setting. The National Institute for Health and Care Excellence (NICE) recommends progressive rehabilitation programmes are best initiated within the first 30 days (postacute phase) to have greatest impact on recovery.[4] The sequelae in those who survive this illness will potentially dominate medical practice for years and rehabilitation medicine should be at the forefront of guiding care for the affected population. These recommendations have been produced using an evidence-based consensus to direct medical care and rehabilitation, based on fledgling evidence from COVID-19 survivors and lessons learnt from previous CoV epidemics.

AIMS

The aim of this consensus statement is to provide an overarching series of recommendations by assimilating the current evidence base for, and likely requirements of, rehabilitation post-COVID-19. The intended patient target is an active population, including military personnel and athletes with the desire to optimise recovery and human performance in occupational settings.

METHODOLOGY

The rehabilitation physician cadre at Defence Medical Rehabilitation Centre (DMRC) Stanford Hall held an initial meeting in person and by videoconference link on 6 April 2020 to discuss the aims of this statement (defined above) and a chair was appointed (SB). The meeting chair facilitated the organisation of the authors into seven teams consisting of at least two authors per team. The authors were consultants or specialty registrars in rehabilitation medicine (eleven), sport and exercise medicine (SEM) (nine), general practice (six), rheumatology (six), anaesthetics (one) or psychiatry (one) with several dual accredited. In addition, there was one specialist pain nurse and one clinical psychologist. The seven teams appraised the evidence for one of the following domains in relation to COVID-19 rehabilitation requirements: pulmonary, cardiac, SEM, mental health, musculoskeletal, neurorehabilitation and general medical. Literature search terms included ‘Coronavirus’, ‘COVID-19’, ‘severe acute respiratory syndrome/SARS’, ‘Middle Eastern respiratory syndrome/MERS’ and were combined in multiple strings using the Boolean operator AND with the following terms ‘Rehabilitation’, ‘Recovery’, ‘Complications’, ‘Exercise’ and ‘Sport’. Databases searched included PubMed, Google Scholar and specific COVID-19 repositories produced by *Journal of the American Medical Association* and *The Lancet* over the period 7 April 2020 to 13 April 2020. Papers were identified with relevant titles and abstracts reviewed. Articles were reviewed if they were, (1) Written in English. (2) Appeared to provide relevant information on the relationship between the first set (domain-related) and second set of (rehabilitation-related) search terms. Each full text was reviewed, and key lessons extracted in line with the overarching aim of this guideline. Relevant cited articles were then sourced where they appeared to represent the original research on which recommendations could be made. Relevant other literature that was known to the authors was included where there appeared to be gaps in the scope of this guideline. In order to ensure that this consensus statement was contemporaneous with emerging evidence, some articles in preprint were included and the intention is that this statement will be updated as new evidence becomes available. A first pass set of recommendations were generated in each team, and combined by the chair (SB), three co-chairs then formed a writing committee (RB-D, OOS, KPPS) and prepared a second pass consensus statement. The Oxford levels of evidence[5] were checked and applied to each guideline recommendation at this stage by the writing committee. Recommendations that could not be ascribed to a citable level of evidence were flagged to originating teams and either amended or removed. The chair was designated to make a final decision in the event of conflict. A manuscript was prepared in accordance with the appraisal of guidelines research and evaluation checklist.[6] In total 39 provisional recommendations were circulated to all authors with a scoring sheet (see online supplementary data) 5 days prior to an agreement meeting. Each recommendation was graded on a Likert Scale, 0–10, with 0 indicating complete disagreement, 5 neither agreement nor disagreement and 10 complete agreement as described by Griffin.[7] In a meeting led by the chair held on 27 April 2020, final changes to recommendations were proposed until an average score of at least 7.5 was achieved. This meeting was attended by all authors in person or by videoconference. After discussion 36 recommendations were agreed and three removed (see online supplementary data). Mean scores for each recommendation were calculated along with 95%CIs calculated in SPSS V.23 (IBM, USA). The final manuscript was then checked and agreed on by all authors prior to submission.

General recommendations for patients with COVID-19

In the UK it has been proposed that up to 50% of hospitalised patients with COVID-19 may require ongoing care with the goal of improving long-term outcomes.[8] A model for delivery via MDTs has been suggested as a way of managing the rehabilitation of these patients in dedicated ‘Centres of Excellence’.[8] The British Society of Rehabilitation Medicine (BSRM) have recently published a position statement that includes the rehabilitation care pathways and coordinated networks that will be required following the COVID-19 pandemic.[9] The BSRM position statement also identifies potential rehabilitation needs at an individual and organisational level following the COVID-19 pandemic. The current study compliments the BSRM position statement by expanding on the potential rehabilitation needs at an individual level, specific to pulmonary, cardiac, SEM, psychological, musckuloskeletal, neurorehabilitation and general medicine by drawing on the evidence available to date. Severe infections leading to respiratory distress with similar diseases, including SARS and MERS, show persistent issues for at least a year post recovery. This underlines the requirement for rehabilitation at local, regional and national levels, dependent on level of impairment.[10 11]

Rehabilitation is patient-centred and tailored to individual patient needs; any rehabilitation programme should take into account comorbidities that may affect a patient’s progress or ability to partake in a programme.[12] Education plays a key part in any successful rehabilitation programme. As COVID-19 is a novel disease, education around the implications of the disease and potential consequences will need to be discussed with patients.[13] There is a paucity of evidence-based guidelines regarding rehabilitation following COVID-19. There is a need for further research around sequelae of COVID-19 and the long-term impact it may have on individuals. COVID-19 has a variable impact on different individuals, ranging from very mild to severe symptoms requiring ICU admission.

A significant number of patients with COVID-19 requiring rehabilitation will have spent time on ICU and will have symptoms common to other ICU patients including dyspnoea, anxiety, depression, prolonged pain, impaired physical function and poor quality of life (QoL).[14 15] This combination of physical, cognitive and psychological issues is known as postintensive care syndrome (PICS).[16] A holistic approach to managing these issues should be considered.[13] COVID-19 is an infectious disease with potentially severe complications whose full impact is yet to be understood, so it would be prudent to closely monitor patients throughout any suggested rehabilitation process.[13]

Box 1 General rehabilitation recommendations

1. Clinicians should follow preventive measures, wear appropriate personal protective equipment according to local policy and measures should be taken to avoid or reduce, the risk of aerosol generation during interventions and activities. Level of evidence: Level 5.
 Level of agreement: mean score 9.23 (95% CI 8.66 to 9.91).
2. Rehabilitation treatment plans should be individualised according to the patient's needs, taking into consideration their comorbidities. Level of evidence: Level 5.
 Level of agreement: mean score 9.70 (95% CI 9.46 to 9.97).
3. For patients with COVID-19, rehabilitation should be aimed at relieving symptoms of dyspnoea, psychological distress and improving participation in rehabilitation, physical function and quality of life. Level of evidence: Level 5.
 Level of agreement: mean score 9.48 (95% CI 9.11 to 9.85).
4. Patients should be reviewed through the rehabilitation process. Level of evidence: Level 5.
 Level of agreement: mean score 8.90 (95% CI 8.23 to 9.58).
5. Patients should receive education about their condition and given strategies on how to manage recovery. Level of evidence: Level 5.
 Level of agreement: mean score 9.23 (95% CI 8.73 to 9.85).

According to existing guidelines rehabilitation should be delivered throughout the patient journey starting from the patient's admission, through to ward care and then following discharge[4] to the most appropriate destination.[9] Early mobilisation has shown to be practical and safe in an ICU setting.[17] The highly infectious nature of COVID-19 will constitute an added obstruction, it is important that infection prevention control measures are adhered to. Personal protective equipment (PPE) will need to be used according to local policy and every attempt to reduce and or avoid the risk of aerosol generation during any activity should be taken.[18 19]

Pulmonary sequelae and rehabilitation recommendations

Although COVID-19 is novel,[20] there have been previous outbreaks of CoV SARS.[21] Lung function testing at 6–8 weeks after hospital discharge following SARS showed mild or moderate restrictive pattern consistent with muscle weakness in 6%–20% of subjects.[22] A prospective cohort study of 94 SARS survivors reported persistent pulmonary function impairment in around a third of patients at 1 year follow-up. The health status of these SARS survivors was also significantly worse compared with the healthy population.[23] A prospective cohort study of 97 SARS survivors demonstrated 27.8% had abnormal chest radiograph findings as well as persisting reductions in exercise capacity (6-minute walk test (6MWT)) at 12 months.[24]

Beyond respiratory function a prospective cohort study of 171 SARS survivors demonstrated deficits in cardiorespiratory (6MWT) and musculoskeletal performance (handheld dynamometry for major muscle groups), as well as QoL compared with age-matched norms.[25] A similar picture was reported following the 2009 H1N1 influenza epidemic.[26]

Pulmonary rehabilitation (PR) has been advocated for several decades as a way to provide comprehensive care and improve the functional status of patients with respiratory diseases.[27] PR is geared towards the unique problems and needs of each patient and is delivered by an MDT of healthcare professionals. It can be defined as '*a multidisciplinary intervention based on personalised evaluation and treatment which includes, but is not limited to, exercise training, education, and behavioural modification designed to improve the physical and psychological condition of people with respiratory disease*'.[28]

PR reduces symptoms, increases functional ability and improves QoL in individuals with respiratory disease, even in those with irreversible abnormalities of lung architecture. These benefits are from treating the secondary morbidities causing the impairment and improve function rather than the respiratory disorder per se. Following COVID-19, especially in those requiring ICU care, this is likely to be dominated by; peripheral muscle dysfunction (due to deconditioning and decreased lean body mass, ICU neuropathy, fatigue and the effects of hypoxaemia), respiratory muscle dysfunction (dysfunctional breathing pattern, DBP, and exercise-induced laryngeal obstruction), cardiac impairment and deconditioning, and psychosocial factors (anxiety, depression, guilt, sleep disturbance and dependency).[28]

Most literature on PR is reported in older populations with chronic obstructive pulmonary disease or younger groups with asthma, however there is evidence available to support the use of PR in pneumonia,[29 30] interstitial lung disease (ILD) and SARS[31] as well as emerging reports of PR being used in the early stages of COVID-19.[32]

PR programmes can be delivered within a hospital setting, outpatient, home-based or even remotely supervised, with the majority in the UK outpatient based.[33 34] Duration of international inpatient PR programmes ranges from 6 weeks to 9 weeks, some providing ongoing maintenance programmes beyond the initial phase. Several PR studies in pneumonia and ILD have been conducted over 8 weeks.[33 34]

PR involves optimisation of medical management, exercise prescription, patient education, psychosocial support and intervention, behavioural modification strategies and vocation-specific support. This is in order to increase functional exercise capacity, improve QoL, reduce sensations of dyspnoea and return to vocational activity.[28]

Exercise training (ET) is considered the foundation of PR and included in 76%–100% of programmes internationally.[33–35] ET is based on general principles of exercise physiology: duration, intensity, frequency, specificity and reversibility. Implicit in the recommendation is the requirement for exercise testing to prescribe individual thresholds and workloads in PR.[28] A Delphi method has been used to develop a clinical management algorithm for mobilisation of critical care patients and recommends the monitoring of heart rate, pulse oximetry and blood pressure during activity.[36] The initial activities listed in this algorithm can be described at the level of 1–3 metabolic equivalent of tasks (METs) or equivalent, for example, rating of perceived exertion.[37]

Cardiac sequelae and rehabilitation recommendations

COVID-19, similarly to other CoVs, is associated with cardiac complications, in particular, arrhythmias and myocardial injury.[38–40] Cardiac complications are likely to be multifactorial and may result from viral myocardial injury, hypoxia, ACE2-receptor downregulation, hypotension, elevated systemic inflammatory burden or drug toxicity.[38] It is suggested that the proinflammatory mediators implicated in COVID-19 play an important role, resulting in vascular inflammation, myocarditis and arrhythmic complications.[38 39] Acute cardiac injury, as determined by elevated cardiac biomarkers, has been described as higher in those with increased mortality, severe disease and those requiring ventilatory support.[38 39] Higher mortality risk has been

Box 2 Pulmonary rehabilitation recommendations

6. Respiratory complications should be considered in post-COVID-19 patients as they may present with some degree of impairment and functional limitation, including but not exclusively, due to decreased respiratory function. Level of evidence: Level 2b.
   Level of agreement: mean score 9.38 (95% CI 8.92 to 9.85).
7. Initial assessment is recommended in a timely manner when safe to do so, depending on the degree of dysfunction, normocapnic respiratory failure and patient's physical and mental status. Level of evidence: Level 2b.
   Level of agreement: mean score 9.00 (95% CI 8.48 to 9.52).
8. Low intensity exercise (≤3 METs or equivalent) should be considered initially particularly for patients who required oxygen therapy, while concurrently monitoring vital signs (heart rate, pulse oximetry and blood pressure). Gradual increase in exercise should be based on their symptoms. Level of evidence: Level 5
   Level of agreement: mean score 8.90 (95% CI 8.23 to 9.57).

identified in those who are of male sex, advanced age and have other comorbidities including hypertension, diabetes mellitus, cardiovascular diseases, and cerebrovascular diseases.[39]

As for most other complications of COVID-19, there are sparse evidence-based management guidelines for COVID-19-related cardiac sequelae. Any patient with COVID-19 infection would require an assessment of their symptoms, recovery, function and potential impairments. Depending on the patient's initial assessment and symptoms, further investigations may include a specialist blood panel, resting electrocardiogram (ECG), 24-hours ECG, echocardiogram, cardiopulmonary exercise testing and cardiovascular magnetic resonance (CMR) imaging with the involvement of a cardiology specialist.[41 42]

A period of 3–6 months of complete rest from training programmes has been proposed for any athlete suffering from myocarditis.[41] The period of rest is dependent on the clinical severity and duration of illness, left ventricular function at onset and extent of inflammation on CMR. Athletes are required to undergo periodic reassessment due to an increased risk of silent clinical progression, in particular during the first 2 years. Training and competition may resume if left ventricular systolic function is normal, serum biomarkers of myocardial injury are normal and if relevant arrhythmias are ruled out on 24-hour ECG monitoring and exercise testing.[41] The above guidance is appropriate to follow in the young and active population that suffer COVID-19-related cardiac injury resulting in myocarditis.

Cardiac rehabilitation (CR) is prioritised for individuals with a diagnosis of heart disease such as acute coronary syndrome, coronary revascularisation and heart failure.[43 44] The British Association for Cardiovascular Prevention and Rehabilitation specify the following six core components for CR: health behaviour change and education, lifestyle risk factor management, psychosocial health, medical risk management, long-term strategies and audit and evaluation.[43] CR is now recommended in international guidelines, with increasing evidence that CR can improve exercise capacity, QoL, psychological well-being as well as reduce mortality, morbidity and unplanned hospital admissions.[43–47] Formal CR programmes usually begin several weeks or months after the cardiac event. The process starts much earlier with education, protection, mobilisation and reassurance. The final aim is for subjects to return to work in a physically and

Box 3 Cardiac rehabilitation recommendations

9. Cardiac sequelae should be considered in all patients post-COVID-19, regardless of severity, and all patients should have an assessment of their cardiac symptoms, recovery, function and potential impairments. Depending on the patient's initial assessment and symptoms, specialist advice should be sought, and further investigations may include a specialist blood panel, ECG, 24-hour ECG, echocardiogram, cardiopulmonary exercise testing and/or cardiac MRI. Level of evidence: Level 5
   Level of agreement: mean score 8.52 (95% CI 7.77 to 9.28).
10. A period of rest postinfection, depending on symptoms and complications, will reduce risk of postinfection cardiac failure secondary to myocarditis. Level of evidence: Level 5
    Level of agreement: mean score 9.19 (95% CI 8.70 to 9.68).
11. If cardiac pathology is present, specific cardiac rehabilitation programmes should be provided tailored to the individual based on their cardiac complications, impairments and rehabilitation needs assessment. Level of evidence: Level 5
    Level of agreement: mean score 9.43 (95% CI 9.03 to 9.82).
12. Patients returning to high-level sport or physically demanding occupation following confirmed myocarditis require a 3–6 months period of complete rest. The period of rest is dependent on the clinical severity and duration of illness, left ventricular function at onset and extent of inflammation on CMR. Level of evidence: Level 2b
    Level of agreement: mean score 9.19 (95% CI 8.64 to 9.74).
13. Training and high-level sport may resume following myocarditis, if left ventricular systolic function is normal, serum biomarkers of myocardial injury are normal and if relevant arrhythmias are ruled out on 24-hour ECG monitoring and exercise testing. Level of evidence: Level 2a
    Level of agreement: mean score 9.00 (95% CI 8.44 to 9.56).
14. If returning to high-level sport or physically demanding occupation following myocarditis, patients are required to undergo periodic reassessment, in particular during the first 2 years. Level of evidence: Level 2a
    Level of agreement: mean score 9.05 (95% CI 8.65 to 9.44).

psychologically fit state with improvement in quantity and QoL. It is likely that COVID-19 may result in an increase in those requiring CR due to exacerbation of common cardiovascular diseases mentioned above. However, there may also be those requiring rehabilitation due to cardiac sequelae in the absence of significant pre-existing cardiovascular disease. Traditional CR may need to be adapted to suit this novel group of patients that may emerge during this pandemic of COVID-19.

Exercise advice and rehabilitation recommendations

Concerns for physically active populations will include the extent to which COVID-19 may impact on athletic development and how to exercise safely. Data from SARS in children indicated a full clinical recovery without perceptible reduction in exercise tolerance. Up to 34% of cases demonstrated changes on high-resolution computed tomography (HRCT) and up to 10% changes in pulmonary function tests (PFTs) at 5–6 months follow-up.[48 49] Requirement for oxygen and lymphopenia during the acute phase of illness were predictive of HRCT abnormalities.[49] PFT changes were demonstrated in some patients who required oxygen during acute treatment.[48] The HRCT abnormalities most frequently found were ground glass opacification and air trapping.[48 49] An early case series of 138 patients with COVID-19 with a median age of 56 describes either ground glass opacities or bilateral patchy shadows on HRCT occurring in all cases.[40] The significance of such findings for optimal human performance is uncertain at this stage and warrants further longitudinal investigation.

Concerning return to exercise post-COVID-19, some general precautions seem prudent; one review article suggests monitoring temperature before training, laundering sports clothing daily and starting with a muscle strengthening programme prior to cardiovascular work.[50] Extending rest and isolation periods in certain cohorts may be necessary. A large prospective cohort study in influenza A cases indicated that obese patients shed viral load for 42% longer duration than non-obese (mean 5.23 vs 3.68 days, respectively).[51] This indirect evidence should be taken with caution but given the rapid spread of COVID-19, a conservative approach rather than an accelerated return would be prudent until more evidence emerges.

Another consideration is dosage of exercise. A case-control study found reduced tumour necrosis factor-α and interleukin-6 levels of secretion in response to non-antigen stimulation in a group who regularly engaged in badminton compared with sedentary controls. Increased T helper cells (Th)1 and Th2 cytokine levels after stimulation with hepatitis B surface antigen and *Streptococcus pyogenes* were also found in the regular exercising group compared with the sedentary group.[52] The conclusion was that moderate activity promotes a healthy immunological response to infection, and possibly suppresses autoimmune activity in the absence of infection whereas reduced activity impairs immune response to infection. A review article cites a randomised control trial demonstrating prolonged antibody response to influenza vaccination associated with exercise.[53] A significantly greater proportion of participants randomised to supervised cardiovascular exercise compared with supervised balance and flexibility training exhibited seroprotective responses at 24 weeks follow-up.[54] The article makes the point that while moderate activity in influenza-infected mice results in reduced mortality, prolonged activity resulted in increased symptoms.[53]

Another review states physical inactivity leads to increased insulin resistance which in turn impairs immune response against microbial agents including macrophage activation and proinflammatory cytokines.[55] This is founded on a case series of older adults subjected to a period of reduced physical activity demonstrating increased insulin resistance and proinflammatory macrophage activity.[56] The review article postulates that physical inactivity predisposes to infection and that physical activity can enhance response to vaccination in influenza.[55] Exercise may play a key role in influencing the immune response, which could be of particular relevance as it seems COVID-19 deterioration after day 7 is related to a hyperimmune phase similar to SARS.[40 57] It should be clarified however that physical activity is not recommended as a treatment for COVID-19.

Severe symptoms are more likely to indicate significant involvement of the cardiopulmonary systems, recommendations for which are made in the sections above, and return to training for this group needs to be more cautious. Recommendations have been made for absolute contraindications to exercise, in patients with significant symptoms (listed in recommendation 16) that are more likely to be indicative of COVID-19.[53] The 'neck check' has been traditionally used for athletes, advising them to exercise, only if they are suffering from 'above the neck' symptoms such as nasal congestion and sneezing and to refrain from exercise if they have 'below the neck' symptoms such as fever, cough or shortness of breath. This advice has been refuted in COVID-19 in favour of a more conservative approach.[58] A period of 2–3 weeks is postulated to recommence return to activity based on the time typically taken to mount an adequate cytotoxic T cell response.[53] A stratified approach promoting safe engagement in physical activity is therefore recommended.

Box 4 Exercise rehabilitation recommendations

15. Patients with COVID-19 who required oxygen therapy or exhibited lymphopenia acutely should be identified and tested for radiological pulmonary changes and pulmonary function test abnormalities. Level of evidence: Level 4.
Level of agreement: mean score 8.95 (95% CI 8.49 to 9.42).
16. Patients with COVID-19 who experience the following symptoms: severe sore throat, body aches, shortness of breath, general fatigue, chest pain, cough or fever should avoid exercise (>3 METs or equivalent) for between 2 weeks and 3 weeks after the cessation of those symptoms. Level of evidence: Level 5.
Level of agreement: mean score 9.19 (95% CI 8.77 to 9.61).
17. With very mild symptoms which may or may not be due to COVID-19, consider limiting activity to light activity (≤3 METs or equivalent) but limit sedentary periods. Increase rest periods if symptoms deteriorate. Prolonged exhaustive or high intensity training should be avoided. Level of evidence: Level 5.
Level of agreement: mean score 8.62 (95% CI 7.86 to 9.37).
18. Asymptomatic contacts of positive COVID-19 cases should continue to exercise as they would do normally within current government restrictions. Level of evidence: Level 5.
Level of agreement: mean score 9.19 (95% CI 8.74 to 9.64).
19. On return from mild/moderate COVID-19 illness to exercise, 1 week of low-level stretching and light muscle strengthening activity should be trialled prior to targeted cardiovascular sessions. Patients in the severe category should be identified as per recommendation 15 above with exercise progression following a pulmonary rehabilitation approach (defined further in the pulmonary section of the main text). Level of evidence: Level 5.
Level of agreement: mean score 8.52 (95% CI 7.85 to 9.19).

Psychological sequelae and rehabilitation recommendations

Reviewing the impact of previous CoV epidemics on mental health demonstrates high levels of emotional distress as a result of anxiety, depression, fearfulness and stigmatisation.[59] These problems occurred in patients, healthcare workers (HCWs) and their families. Acutely, there were problems with anxiety and depression, and chronically, post-traumatic stress symptoms and post-traumatic stress disorder (PTSD). Corticosteroid treatment was implicated in the development of psychotic symptoms,[59] but this should be reduced following COVID-19 given the recommendations from the World Health Organisation (WHO) to re-evaluate their use.[60]

There was some resolution in mental health problems in the months immediately following the infection, however, symptoms remained in a significant proportion of the population into the chronic phase. Following SARS, 5%–44% suffered a decrease in mental health at 1 year including anxiety, depression, psychosis and high rates of PTSD.[11 22 59] There were many reasons for this, including its life-threatening nature, worries for family members and concern with becoming a vector for infecting

Box 5 Psychological rehabilitation recommendations

20. In the acute phase, effective communication, social contact (although remotely) and an information sheet for people admitted to acute National Health Service care regarding the psychological sequelae of COVID-19 could help. Level of evidence: Level 5.
    Level of agreement: mean score 8.86 (95% CI 8.33 to 9.38).
21. Individuals should be reviewed in the recovery phase to identify those who may have adverse psychological outcomes as a result of their COVID-19 experiences. Healthcare workers who contracted COVID-19 should be considered a high-risk group. This review should focus on mood and well-being. Level of evidence: Level 5.
    Level of agreement: mean score 9.14 (95% CI 8.64 to 9.65).
22. Active monitoring (ongoing review) should be undertaken for those with subthreshold psychological symptoms. Level of evidence: Level 1a.
    Level of agreement: mean score 8.81 (95% CI 8.11 to 9.51).
23. Referral to psychological services and consideration of trauma focused cognitive behavioural therapy, cognitive processing therapy or eye movement desensitisation and reprocessing is appropriate for those with moderate to severe symptoms of acute stress disorder. Level of evidence: Level 1a.
    Level of agreement: mean score 8.76 (95% CI 8.17 to 9.35).

others. Following MERS, at 12 months and 18 months, 27% and 17% of survivors had depression and 42% and 27% had PTSD symptoms.[61] Based on previous epidemics, it is possible that up to 30% of COVID-19 survivors will need further input, that is, will not naturally process their traumatic experiences,[59] some of which will be COVID-19-related and some of which will be related to the psychological impact of PICS.

There will also be a burden on HCWs as they will likely also experience mental health sequelae. Following SARS, being a HCW predicted a significantly lower QoL, attributed to the anticipatory anxiety of returning to a workplace that was the scene of their traumatic experience. This finding was also seen following MERS, with one study in South Korea demonstrating 57% of nurses suffered PTSD.[62] Overall, while being a HCW confers some psychologically protective elements, the evidence suggests being a HCW leads to worse outcomes.[59]

NICE recommends assessment for all who have sustained trauma, using active monitoring to follow-up with subthreshold symptoms and offer cognitive behavioural therapy, cognitive processing therapy or eye movement desensitisation and reprocessing in those who are symptomatic in the postacute and intermediate phases.[63]

Musculoskeletal sequelae and rehabilitation recommendations

The exact musculoskeletal consequences for patients with COVID-19 has not yet been established. Patients who have been admitted to ICU during previous epidemics have suffered musculoskeletal complications that have required rehabilitation.[22]

It is well recognised that patients ventilated within ICUs are prone to weakness and physical impairments not directly attributable to their primary disease process.[64–66] Prolonged mechanical ventilation and immobilisation associated with ICU admissions result in musculoskeletal changes. ICU acquired weakness encompasses critical illness associated polyneuropathy, myopathy and neuromyopathy.[64 67] Muscle atrophy and loss of muscle mass starts during the first week of ICU admission and is worse in patients with multiorgan failure, sepsis or prolonged ICU stay.[65 68] Other musculoskeletal complications resulting in reduced fitness include heterotopic ossification, muscle wasting, prolonged pain, weakness and dyspnoea.[11] It was noted that survivors of SARS and non-SARS ARDS had 9%–18% weight loss during their ICU stay.[10 11] Patients surviving ARDS requiring ICU ventilatory care experience impairments affecting muscle strength, walking capacity and physical activity.[69] Following the SARS outbreak in 2003, it was reported from Hong Kong that patients who had recovered had significantly lower 6MWT and below average performance in the curl-up and push-up tests, 2 weeks following hospital discharge.[25]

A notable musculoskeletal complication of SARS was osteonecrosis implicated in steroid therapy in a dose-dependent manner.[70] As the WHO has recommended a balanced approach to the use of steroids for COVID-19 the risk of osteonecrosis should become less likely.[60]

It is recognised that patients requiring ICU input for ARDS often suffer from PICS which includes psychological as well as cognitive issues in combination with physical impairments as described above.[16 71] Following ICU admission, there is evidence to suggest increased nociceptive, neuropathic and nociplastic pain.[14 72] This highlights the need for a MDT assessment for holistic management of rehabilitation of such a patient, including pain, rather than focusing on musculoskeletal impairments in isolation.

Two systematic reviews on exercise rehabilitation following ICU discharge did not find significant improvement in QoL.[17 73] These studies, which are not based on patients with COVID-19, highlight the need to consider the impact of motivation and psychological factors on recovery. Survivors of ICU admissions due to COVID-19 will include a young working cohort. Occupationally focused goal setting offers hope for good QoL outcomes by addressing motivation and psychology. Vocationally focused intensive inpatient rehabilitation has been shown to result in greater functional improvements in comparison to traditional rehabilitation models.[74]

Holistic rehabilitation of patients with complex impairments will require rehabilitation MDTs to address these effectively focused at all three domains of PICS.[14 15] The physical therapy strategy for patients with post-ICU related weakness includes exercise-based interventions such as muscle stretching, weakness and joint range of motion to avoid contractures and pressure sores. Pain management should be patient-centred and involve education, and non-pharmacological and pharmacological interventions. Physical rehabilitation outpatient programmes vary, but typically span 6–12 weeks after discharge and can include patient-directed exercises, in-home therapist sessions, telehealth delivery of therapy and can be bundled with cognitive rehabilitation.[14 15 67]

Neurological sequelae and rehabilitation recommendations

SARS-CoV-2 enters the human body through ACE2 receptors on the surface of human cells, expressed on the surface of the spinal cord, as well as the respiratory tract, suggesting that the central nervous system (CNS) could be vulnerable to SARS-CoV-2.[75] Theories from animal models also suggest that CoV can enter the CNS directly via the olfactory bulb.[76] This might be a cause of hyposmia described in COVID-19.[77]

In a retrospective observational study from China, 78/214 (36.4%) patients with laboratory proven COVID-19 had

Box 6 Musculoskeletal rehabilitation recommendations

24. All patients requiring rehabilitation following COVID-19 should have a functional assessment to determine residual musculoskeletal impairments in order to determine appropriate rehabilitation. Level of evidence: Level 5.
Level of agreement: mean score 9.43 (95% CI 9.03 to 9.82).
25. Patients that have had an ICU admission should have a multidisciplinary team approach for rehabilitation. Level of evidence: Level 5.
Level of agreement: mean score 9.48 (95% CI 9.11 to 9.85).
26. Patients presenting with postintensive care syndrome should include rehabilitation efforts focusing on all three domains of impairments: psychological, physical and cognitive. Level of evidence: Level 5.
Level of agreement: mean score 9.76 (95% CI 9.25 to 10.00).
27. Physical rehabilitation following COVID-19 can be delivered in a series of settings including inpatient, outpatient, in-home telehealth or patient-directed exercises determined according to patient needs. Level of evidence: Level 5.
Level of agreement: mean score 9.76 (95% CI 9.52 to 10.00).

Box 7 Neurological rehabilitation recommendations

28. All patients with COVID-19 should be reviewed for any neurological symptoms, as symptoms can be immediate (at time of active infection) or delayed (in the weeks following COVID-19). Consider a cognitive screen for those at risk (postcritical care or with residual cognitive impairment). Level of evidence: Level 2b.
Level of agreement: mean score 8.48 (95% CI 7.68 to 9.27).
29. Reassurance should be given that milder neurological symptoms like headache, dizziness, loss of smell or taste, and sensory changes are likely to improve with minimal intervention. Level of evidence: Level 4.
Level of agreement: mean score 8.71 (95% CI 8.02 to 9.41).
30. Education should be provided that mild-to-moderate neurological symptoms are likely to have a full recovery. Level of evidence: Level 3b.
Level of agreement: mean score 8.86 (95% CI 8.37 to 9.34).
31. Severe symptoms potentially may result in significant or life-changing impairment, therefore inpatient multidisciplinary rehabilitation is recommended for patients with moderate-to-severe neurological symptoms to maximise recovery. Level of evidence: Level 5.
Level of agreement: mean score 9.43 (95% CI 9.06 to 9.80).
32. Physical, cognitive and functional assessments should be considered to support return to work according to occupational setting. Level of evidence: Level 5.
Level of agreement: mean score 8.71 (95% CI 7.98 to 9.45).

neurological manifestations, more pronounced in severe cases compared with non-severe (45% vs 30.2%).[78] Overall, neurological symptoms fell into three categories: CNS symptoms or disease (headache (13.1%), dizziness (16.8%), impaired consciousness (7.5%), acute cerebrovascular disease (2.8%) and epilepsy (0.5%); peripheral nervous system symptoms including hypogeusia (loss of taste) (5.6%), hyposmia (loss of smell) (5.1%) and neuralgia (2.3%); and musculoskeletal symptoms (10.7%).[78] Headache was also reported in 13.6% of 1099 patients with COVID-19 in a different study from China.[77]

Furthermore, case reports have described COVID-19 complicated by neurological symptoms including encephalitis;[79] encephalopathy;[80] acute necrotising encephalopathy;[81] and postinfectious myelitis leading to acute flaccid paralysis of both lower limbs.[75]

Neurological complications were also seen in previous CoV epidemics. In 2003 the first case of a patient with both laboratory confirmed SARS and detection of SARS RNA in the cerebrospinal fluid (CSF) was reported, with the patient initially presenting with respiratory symptoms then developing confusion followed by *status epilepticus*.[82] In 2004, on day 22 of illness from SARS, a pregnant 32-year-old woman developed general tonic clonic seizures and tested positive for SARS-CoV in her CSF.[83] In 2002–2003, there are case reports in the 664 probable patients with SARS in Taiwan, of polyneuropathy and myopathy developing 3–4 weeks after onset of SARS, with obvious improvement at follow-up.[84] Large artery ischaemic strokes were also described in five patients with SARS from an outbreak in Singapore with poor prognosis.[84]

Following an outbreak of MERS in Korea, 4 of 23 patients were reported as having neurological complications appearing 2–3 weeks after respiratory symptoms.[85] These included Bickerstaff's encephalitis overlapping with Guillian-Barre syndrome (ptosis and ophthalmoplegia plus limb weakness); critical illness neuropathy with limb weakness and peripheral sensory neuropathies.[85] In Saudi Arabia, three patients with MERS requiring ICU support developed severe neurological complications including confusion, coma, ataxia and focal motor deficit.[86] Magnetic resonance imaging (MRI) revealed widespread bilateral hyperintense changes of the white matter and subcortical areas throughout the frontal, temporal, and parietal lobes, basal ganglia and corpus callosum.[86]

Finally, cognitive impairment can occur in patients who have been in ICU as part of PICS. Major risk factors include sepsis, increased age, prior cognitive deficit, ARDS and delirium.[87] This impairment can remain for up to 1 year.[87]

Medical sequelae and rehabilitation recommendations

In the acute phase of COVID-19, there is a high incidence of medical complications, including hepatic, renal, haematological and gastrointestinal (GI), but it is unclear how many of these complications will remain prevalent in the intermediate and chronic phases.[40 88 89] These complications, as a result of COVID-19 directly, or as a result of medical interventions and treatments indirectly, have been associated with high rates of morbidity and mortality.[40] It is therefore important to assess for any abnormalities in the postacute phase and consider the implications of any future interventions on a background of deranged organ function.

GI consequences of COVID-19

COVID-19 presenting features have included diarrhoea and vomiting (2%–10%), preceding dyspnoea, fatigue and fever, with SARS-CoV-2 RNA found in stool samples.[88] Ten per cent of patients with MERS also had diarrhoea as a presenting symptom.[90] No obvious chronic GI sequelae have been identified.[88] Those with pre-existing GI problems are at higher risk, the subsequent recommendation being that steroid therapy should be reduced but other immunosuppression can continue.[88] Decreased appetite and weight loss has been noted secondary to fever, loss of taste and/or smell and low energy/fatigue. COVID-19-related nutritional issues exacerbate other areas, including skin quality, bone health and endocrine function. Also, raised amylase increases significantly the risk of diabetes development in the future.[91]

In the postacute phase, a full GI history is required at rehabilitation assessment to ensure any chronic problems are identified. As diarrhoea can be a presenting complaint of COVID-19, ensuring any diarrhoea and vomiting is promptly isolated, and a CoV test considered seems prudent. Dietician input is valuable early on with supplements where indicated including a micronutrient blood panel if concerned about nutritional input during the acute phase of the illness.[87]

Hepatic consequences of COVID-19

Of the patients with COVID-19, 14%–54% display deranged liver function tests (LFTs) (transaminases, gamma-GT, bilirubin) during the acute phase.[88 89] The cause of this is currently unclear; possibilities include, septic response, hepatic congestion due to mechanical ventilation, COVID-19 induced viral hepatitis or drug toxicity.[88 89] Liver dysfunction has been seen to be more pronounced in severe COVID-19.[88 89] The acute injury is felt to be self-resolving (although some management was indicated for severe acute injury), with no chronic sequelae found yet.[88] Patients with chronic liver failure are at higher risk of severe COVID-19.[88]

It is important to check LFTs, including amylase, during recovery, so persistent abnormalities can be identified and either managed or referred on for management.

Renal consequences of COVID-19

Acute kidney injury (AKI) has occurred in a proportion of patients (22%), but some papers state SARS-CoV2 infection itself does not significantly cause obvious acute renal injury.[92] Possible causes for AKI have been suggested as COVID nephritis, hypoxia, shock, microhaemorrhages and iatrogenic causes (eg, negative fluid balances, drug toxicity).[40] Some patients with AKI and chronic renal kidney injury have required renal replacement therapy.[92] Renal transplant patients are at higher risk of contracting COVID-19 and having a severe infection.

It is important to check renal function where indicated during recovery phase to identify persistent abnormalities and need for further investigation. Patients with abnormalities may need alterations to exercise regimes, hydration advice or referral to specialist services.

Dermatological consequences of COVID-19

COVID-19 is not dermatotrophic, but the main skin related problems are due to worsening pre-existing conditions, iatrogenic PPE-related conditions (in up to 97% HCWs) and those related to increased handwashing.[93] There is an increased pressure sore risk with ICU treatment and recurrent prone positioning.

It is important to promote emollient/barrier cream use for frequent handwashing, monitor for PPE related conditions (for staff and patients) and increased monitoring for pressure areas, especially in the ICU population.

Rheumatological consequences of COVID-19

Following SARS in 2003, a post-SARS syndrome was described, with the same phenotype as postviral chronic fatigue syndrome, similar to fibromyalgia, with poor sleep, fatigue, myalgia and depression, with some unable to return to work as a result.[94] Corticosteroid-induced myopathy, muscle wasting and weakness have also been reported in survivors of ARDS at 1 year follow-up.[10]

A good musculoskeletal assessment should identify areas for non-rheumatologists to address and specialised issues that require a rheumatology review.

Haematological consequences of COVID-19

A retrospective case series of 199 SARS hospitalised patients in Singapore demonstrated that 11 individuals had a deep vein thrombosis, seven suffered from a pulmonary embolism (PE) (four of which suffered both) and a further four patients developed an ischaemic stroke suggesting that patients with SARS had increased susceptibility and prevalence of venous thromboembolism (VTE) as result of a hypercoagulable state.[57]

COVID-19 also has a direct and prominent effect on the haematopoietic system, leading to significant changes to the cell lines and hypercoagulability. In over 1000 cases in China, lymphocytopenia was the most common finding (83.2%), then thrombocytopenia (36.2%) and leucopenia (33.7%), changes which were more prominent in severe disease.[77] As a result, anaemia has been a common problem and this might remain in the intermediate phase. Coagulation disorders are frequently encountered in patients with COVID-19 with an increased risk of vasculopathy and VTE.[95] The British Thoracic Society have released guidance recommending doubling the dose of pharmacological VTE prophylaxis.[96] It is not known this hypercoagulable state lasts for how long, therefore appropriate postacute VTE prophylaxis assessments should be performed and a PE must be considered with any new sudden shortness of breath.

Endocrine consequences of COVID-19

Deranged endocrine and other blood profiles have been seen following ICU spells; it is important to exclude these as organic causes of PICS.

Chronic hyperglycaemia as a result of diabetes mellitus impairs immune function, and 42.3% fatalities in Wuhan had diabetes as a comorbidity.[97] The mechanism underlying this is unclear but it is likely to be related to the role of ACE2, the deficits in innate immune function and propensity to disease severity, and relationship between diabetes, cardiovascular health and age.[98] Potentially, the expression of ACE2 on pancreatic β-cells might lead to damage, insulin deficiency and diabetogenesis.[98]

Sick day rules, which involve increased monitoring of blood sugar and ketones, remaining hydrated and fed, increasing insulin as required and amending other diabetic medication on specialist advice, should be employed if anyone with diabetes develops COVID-19.[98]

Investigations in the postacute phase should include an endocrine screen, to include monitoring for the onset of diabetes, when indicated. Significant bone mineral density (BMD) decrease has been described in ICU patients in the year following admission.[99] Prolonged immobilisation is a risk factor for decreased BMD and dual energy X-ray absorptiometry should be considered.[100]

LIMITATIONS

COVID-19 is a new disease only in circulation since late 2019. As a result, some of the articles cited are in preprint, and are themselves only reporting observational case series, with some journals fast-tracking publication of COVID-19-related research. This has impacted the quality of evidence available. A key driver of this consensus statement has been the timely manner in which it has been produced. Although the current study does not follow a systematic review methodology, levels of the evidence have been applied to each recommendation to mitigate this. In

Box 8 Medical rehabilitation recommendations

33. Post COVID-19 medical sequelae should be considered in all patients. Postacute assessment should include a full medical history and if indicated, an examination and panel of blood markers. Dual energy X-ray absorptiometry should be considered in cases of prolonged immobilisation. Level of evidence: Level 3b.
    Level of agreement: mean score 8.57 (95% CI 7.59 to 9.55).
34. In the presence of multiple pathologies or specialist issues, a rehabilitation consultant assessment is recommended with a multidisciplinary approach to rehabilitation, to manage the wide range of potential sequelae including a dietician (with supplements and micronutrient blood panel if required). Level of evidence: Level 1a.
    Level of agreement: mean score 9.57 (95% CI 9.20 to 9.94).
35. If ongoing medical problems are identified, patients should be referred on to the appropriate medical specialty for further management. Level of evidence: Level 5.
    Level of agreement: mean score 9.76 (95% CI 9.52 to 10.00).
36. In post-COVID-19 patients with new-onset shortness of breath or chest pain, life-threatening medical complications should be considered. Level of evidence: Level 5.
    Level of agreement: mean score 9.62 (95% CI 9.25 to 9.99).

order to produce an initial consensus statement to guide the initial phase of rehabilitation, the authors have aimed to capture a snapshot of current literature, and expect this body to grow, and therefore the authors will aim to update the recommendations accordingly. A period of 6 months has been set to repeat the voting process. The authors have extrapolated lessons from other, related, conditions such as SARS, MERS, ARDS and critical care related illness, in order to provide a likely mechanism of recovery. As this consensus statement is updated, the reliance on data from related conditions will decrease.

DISCUSSION

COVID-19 is a global pandemic affecting individuals to varying degrees, ranging from a few days of mild symptoms to respiratory distress requiring ICU treatment including ventilatory support, and death. It is predicted that 45% of patients discharged from hospital will require support from healthcare and social care and 4% will require rehabilitation in a bedded setting.[8] Therefore, there is a clear need to plan for postacute and chronic rehabilitation of patients recovering from COVID-19. This document has set out the current available evidence for managing and rehabilitating potential key sequelae from COVID-19. Unfortunately, there is sparse evidence and guidance available on how to best rehabilitate such patients. A significant amount of the recommendations set out rely on extrapolating from the management and rehabilitation of complications of previous CoV epidemics. As COVID-19 is predominantly a respiratory infection with severe cases requiring ventilatory support, rehabilitation following ICU treatment is also an area that guidance and evidence has been extrapolated from, to produce these recommendations. These recommendations could be considered the foundation for further evidence-based guidelines and recommendations for rehabilitation of COVID-19-related complications.

This document supports the clear need for further research and guidance regarding rehabilitation specific to COVID-19. The findings identified in this statement have been used to support the DMRC plan for UK military post-COVID-19 rehabilitation. This will facilitate coordinated initial healthcare delivery for both inpatient and outpatient rehabilitation settings.

The UK military delivers a proportion of rehabilitation in a residential setting, with those requiring more intensive treatment historically admitted on a rolling inpatient basis at DMRC, punctuated by periods of home-based rehabilitation allowing for psychological recovery and family adjustment.[101] The residential model receives positive patient feedback[102 103] but when applying these recommendations to civilians it is worth noting patients may be less familiar with geographical separation and may prefer treatment delivery in a more local setting. While it is too early to confirm these opinions in a COVID-19 cohort, DMRC will be seeking further patient feedback and will model for optimal care delivery. The optimal setting for delivery of rehabilitation is an existing and active area of UK military research.[102] Given the large numbers affected by this pandemic so far, capacity and costings may impact on delivery setting. The cost of inpatient rehabilitation at DMRC per day is estimated at £500 (2011 pricing), for example.[104] In concert with requirements for social distancing the rehabilitation of COVID-19 may therefore need increased use of remote delivery and telemedicine. This consensus statement is intended for those planning at a population level for delivery of rehabilitation, leaders and members of MDTs as well as independent primary care and SEM practitioners. Subsequent prospective cohort data capture has been planned in order to determine the validity of these recommendations and optimise future healthcare delivery.

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