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Original research article

Post COVID challenges in chronic neurological conditions: exploring perceived symptoms and the potential effect of individual physiotherapy

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Abstract
Background: COVID is described as having not only medical but also wider social consequences for society. Individuals may experience persistent health problems after infection. We aimed to find out whether people with chronic neurodegenerative disease (multiple sclerosis – MS) still perceive any complications after this infection. And the secondary aim was to offer them a physiotherapy.
Methods: In this single-centre study, people with MS who experienced COVID-19 between January and March 2022 were contacted and structurally asked about the occurrence of any post-COVID symptoms.
Results: In March 2023, 251 (75 men) people responded to the survey. The mean age of these people was 43.8 years (SD 8.9), and the mean disease duration 14.1 years (SD 8.3). A total of 76 people (22%) suffered from post-COVID symptoms lasting 12 weeks or longer. Most common symptoms included fatigue (55%), dyspnoe (26%), neurological deterioration (20%), and joint and muscle pain (18%).A total of 6 people participated in a pilot physiotherapy program.
Conclusion: Based on subjective reports, a considerable number of people with MS can suffer from post-COVID symptoms Our experience from a small pilot study showed that individual physiotherapy could probably relieve some of these difficulties. However, this would need to be verified in a larger sample. Knowledge of any persistent post-COVID difficulties can also help other health and social care professionals.

Keywords: COVID-19; Long-COVID; Multiple sclerosis; Physiotherapy; Post-COVID; Rehabilitation; Telerehabilitation

Introduction

COVID is described as having not only medical but also wider social consequences for society. Individuals may experience persistent health problems and reduced quality of life after infection. Social distance and security measures have also affected relationships among people. The pandemic led to pathological exposure to stress that can lead to anxiety, depression, or even post traumatic stress disorder. Not only fears of contagion with virus but also separation from loved ones, loss of freedom, uncertainty or feeling of helplessness can cause these psychological difficulties (Brüssow and Timmis, 2021). Restrictive pandemic measures also has influenced on life of whole society. So it is possible to speak about so called societal-long COVID with many impacts on society, such as: increase in preventable morbidity and mortality due to delayed diagnostics and treatment process, increase of stress levels and mental health problems, education deficit, reduction of work productivity and economic performance, vulnerability of social service provision, and diminished trust in leaders (Saladino et al., 2020).

A large number of worldwide studies have described the course of COVID-19, even in people with chronic neurological diseases (including multiple sclerosis – MS (Stastna et al., 2021) (Chen et al., 2022; Davis et al., 2023). In contrast, relatively little literature has been devoted to the later consequences of the disease (so-called post-COVID syndrome). The term "post-COVID" or "long-COVID" has been used to refer to these long-prevalent health problems that cannot be explained by alternative diagnosis (Munblit et al., 2022; WHO, 2021). It appears that as many as 65 million people around the world (roughly 10% or more of infected people) (Davis et al., 2023; Huerne et al., 2023) may suffer from certain persistent complications from SARS-CoV-2 infection. Post-COVID syndrome is associated with all ages and acute phase disease severities.

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However, most cases appear in people with a course of mild acute COVID-19 (Davis et al., 2023).

Post-COVID difficulties can affect any part of the organ system (more than 200 symptoms have been identified), including the cardiovascular, respiratory, gastrointestinal, neurological, musculoskeletal, metabolic, renal, dermatological, otorhinolaryngological, and haematological systems. Symptoms of post-COVID syndrome may also contribute to the occurrence of psychological problems and chronic fatigue (Carod-Artal and García-Moncó, 2021; Davis et al., 2023; Lopez-Leon et al., 2021; Ravendeeran et al., 2021). There are likely multiple, probably overlapping, theories for causes of post-COVID syndrome: including persisting reservoirs of virus in tissues (Proal and VanElzakker, 2021; Swank et al., 2023), impact on gut microbiota (Proal and VanElzakker, 2021), immune dysregulation (Davis et al., 2023), blood clotting and endothelial dysfunction (Xie et al., 2022), and dysfunctional signalling in the brainstem and/or vagus nerve (Davis et al., 2023). COVID-19 infection has also been shown to be associated with Epstein–Barr virus (EBV) reactivation (Rousseau and Bhaduri-McIntosh, 2023), and multi-omic investigations have demonstrated that EBV viremia at the initial COVID-19 diagnosis can predict post-COVID-19 syndrome (Su et al., 2022). This is particularly relevant in the context of MS, as recent epidemiological studies confirm a strong link between MS and EBV infection (Bjornevik et al., 2023).

Neurological, musculoskeletal, and cognitive systems are major features of post-COVID syndrome, including muscle aches, joint pain, headaches, cognitive impairment (called brain fog), sleep disorders, sensorimotor symptoms, etc. These neurological and cognitive symptoms often have delayed onset months after infection, whereas, for example, respiratory problems (dyspnea, cough, etc.) were more common within weeks after infection. However, the onset and time course of symptoms differ across individuals (Davis et al., 2023). Performing physical activities can also be limited by post-exertional malaise (Appelman et al., 2024) and cardiorespiratory symptoms (tachycardia, palpitation, chest pain, etc) (Davis et al., 2021). Post-exertional malaise also occurs after other infectious diseases, critical illnesses, and sepsis. However, other unexplained persisting trends are unique to the SARS-CoV-2 virus, such as the expected prognosis of long-COVID recovery, or the difference in incidence and disease severity between COVID-19 variance (Huerne et al., 2023). In people with long-COVID syndrome, changes in skeletal muscle structure were found, such as a higher proportion of highly fatigable glycotic fibers and lower mitochondrial function that can partly explain pathophysiology of post-exertional malaise (Appelman et al., 2024).

A 2021 systematic review that analysed 15 studies evaluating the long-term effects of COVID-19 found that long-term symptoms of the disease persisted for 14 to 110 days after viral infection (Carod-Artal and García-Moncó, 2021). However, long-COVID syndrome is defined as the persistence of symptoms that are newly developed in association with an infection and last for more than three months (Munblit et al., 2022).

Studies describing the prevalence of difficulties after COVID have often focused on the general population (Carod-Artal and García-Moncó, 2021; Ceban et al., 2022; Chen et al., 2022; Davis et al., 2023; Huerne et al., 2023) and have not considered the prevalence of these difficulties in specific patient groups that health and social care professionals encounter in their practice. Our aim was, therefore, to investigate the possible occurrence of post-COVID difficulties (or long-COVID symptoms) in a group of people with chronic neurological disease (MS). The second aim of this pilot study was to evaluate whether the intervention of a physiotherapist could influence some of their difficulties.

Materials and methods

Sample

This monocentric study was conducted in the Department of Neurology at the First Faculty of Medicine and General University Hospital in Prague. The research was carried out within the MS Centre of the Neurology Department. During the COVID-19 pandemic, a systematic approach was employed to gather data from all monitored people, encompassing approximately 4,000 individuals diagnosed with MS. During their clinical visits, these people were queried regarding their COVID-19 infection status and vaccination history (as described previously) (Stastna et al., 2021, 2022).

The study specifically targeted people who experienced COVID-19 infection between January and March 2022, a period characterised by the predominance of the Omicron variant in Czechia. This temporal selection was deliberately made to mitigate potential biases by ensuring the inclusion of people who encountered the same variant of the SARS-CoV-2 virus. Subsequently, these people were contacted to collect relevant data for the study.

Assessment

Patients were interviewed using a semi-structured questionnaire administered by healthcare professionals (physiotherapists). The interview aimed to assess the duration and extent of any health difficulties perceived by patients following COVID-19, and to determine their interest in potential rehabilitation interventions. The questionnaire included inquiries about the occurrence, severity, and duration of any post-COVID symptoms experienced by the patients. In cases where patients reported perceived difficulties, they were offered the opportunity to participate in an outpatient physiotherapy program.

Pilot physiotherapy program

The pilot physiotherapy program addressed the most frequently experienced symptoms among the patients. The six-week therapeutic program included one-hour sessions with a physiotherapist each week. These sessions incorporated elements of respiratory physiotherapy (breathing localised to different parts of the chest, training of prolonged exhalation, correction of breathing pattern), muscle relaxation techniques, posture correction, and individual guidance on appropriate aerobic training. Additionally, patients were instructed to perform breathing and stretching exercises independently at home for about 10 minutes each day. Patients were provided with exercise descriptions and photos for home exercises (available online: www.msrehab.cz). Based on the therapist's recommendations and the patient's abilities, the regimen gradually included strengthening exercises and intermittent aerobic activities. Telerehabilitation in this small pilot group was implemented as a synchronous, i.e., real-time online call with a physiotherapist (of the same duration as a regular outpatient physiotherapy session). Given this, the therapeutic techniques focused primarily on breathing pattern re-education and instruction in stretching the accessory breathing muscles, with advice on additional appropriate loading where appropriate. Thus, these were techniques that, in our opinion, could be

implemented with comparable quality to conventional outpatient physiotherapy.

Before and after the exercise program, patients underwent individualised examinations by a physiotherapist. These examinations primarily focused on posture, breathing, and painful or problematic movements. Baseline and follow-up assessments included measurements of chest and abdomen mobility (assessing minimum and maximum breathing excursions in cm), evaluation of breathing patterns (qualitative assessment by a physiotherapist), and assessment of perceived fatigue using the Modified Fatigue Impact Scale (MFIS) questionnaire (min 0 max 84, with a higher score indicating higher fatigue level) (Fisk et al., 1994). Patients interested in physical therapy could choose between regular outpatient sessions or an online tele-rehabilitation program for those who might have difficulty attending in-person sessions once a week. Both types of programs were designed the same, but the goal was to allow those with more distant residences to participate in the program.

Statistical analysis

Basic descriptive statistics, including demographic characteristics and the prevalence of individual symptoms, were performed using Microsoft Excel. For statistical comparison between patients with and without perceived difficulties, *t*-tests were conducted using SPSS Statistics version 22.

Results

Characteristics of participants

In March 2023, out of 345 people (103 men) who experienced COVID-19 between January and March 2022, a total of 251 (75 men) responded to the semi-structured questionnaire. The mean age of all participants was 43.8 years (SD 8.9), with a mean disease duration of 14.1 years (SD 8.3). The median level of neurological disability, as measured by the Expanded Disability Status Scale (EDSS), was 2.5 (range 0–7.5). A group of 94 non-responders were repeatedly unreachable by telephone, with only one person directly refusing to participate in the research.

Of the respondents, 107 patients reported experiencing persistent difficulties after the infection. Of these, 76 individuals (22% of the sample) reported post-COVID symptoms lasting 12 weeks or longer. Detailed demographic and clinical characteristics of the participants are described in Table 1. Statistical analysis revealed no significant differences between patients with post-COVID difficulties and those without in terms of age ($p = 0.362$), disease duration ($p = 0.425$), or level of disability ($p = 0.175$).

Table 1. Detailed demographics and clinical characteristics of the study population

	People without any post-COVID symptoms ($n = 144$)	People with some post-COVID symptoms ($n = 107$)	People with post-COVID syndrome (symptoms ≥12 weeks) ($n = 76$)	People who failed to be contacted ($n = 94$)
Gender (w/m)	93/51	83/24	59/17	66/28
Mean age (years)	43.56 (SD 9.16)	44.08 (SD 8.27)	45.78 (SD 8.01)	44.14 (SD 9.84)
Mean disease duration (years)	13.81 (SD 8.26)	14.35 (SD 8.15)	14.98 (SD 8.34)	13.57 (SD 7.68)
Median neurological disability (EDSS scale)	2 (range 0–7.5)	2.5 (range 1–7)	3 (range 1–7)	2.5 (range 1–8)
Disease-modifying therapy (no/platform treatment/ high-efficacy treatment)	7/51/86	8/37/62	7/26/43	15/39/40

Platform treatment includes: interferons, glatiramer, teriflunomid and dimethyl fumarat.
High-efficacy treatment includes: anti-CD20, natalizumab, alemtuzumab, S1P, cladribine.

Perceived post-COVID symptoms

The most commonly reported symptoms included fatigue (55%), dyspnea (26%), neurological deterioration (20%), joint pain and muscle ache (18%), headaches (7%), sleep disturbances, (6%) and other symptoms (17%). At the time of the survey, 41 individuals still suffered from these symptoms. A total of 52 participants (48%) reported more than one symptom. A detailed list of subjectively perceived symptoms is displayed in Table 2.

In eight people with post-COVID symptoms, neurologists also evaluated changes in neurological disability. Among these people, one improved, two worsened by 1 EDSS grade, and five worsened by 0.5 EDSS grades/levels. The severity of symptoms was rated as mild or moderate by 64 individuals (60%), severe and very limiting by 26 individuals (24%), and unspecified by 17 individuals (16%). In the group of people whose symptoms met the definition of the post-COVID syndrome, 44 expressed interest in rehabilitation (58%), with six of these being interested only in receiving an informational leaflet rather than participating in any exercise interventions. Of those interested in rehabilitation, six patients were finally able to agree to participate in the program.

Pilot physiotherapy program

A total of six patients (one man) participated in a pilot program to address post-COVID difficulties. Three participants opted for regular outpatient physiotherapy, while the remaining three chose the telerehabilitation option, with both formats involving six weeks of 60-minute therapy sessions. The physiotherapy program was designed to train localised breathing and correct breathing stereotypes, stretch auxiliary respiratory muscles, and activate the postural muscles of the spine. Upon completion of the physiotherapy program, participants reported several benefits. There was a mean reduction of 12 points in the Modified Fatigue Impact Scale (MFIS) questionnaire, indicating a decrease in fatigue. Participants also perceived a reduction in dyspnea and showed improvements in respiratory stereotypes. The program appeared to be effective in both face-to-face and online formats. Detailed participant characteristics and program evaluations are provided in Tables 3 and 4.

Table 2. Incidence of post-COVID symptoms

People with some post-COVID symptoms	*N* = 107	People with post-COVID syndrome (symptoms ≥12 weeks)	*N* = 76
Fatigue	59	Fatigue	40
Dyspnea	28	Dyspnea	21
Cough	14	Cough	7
Joint pain	12	Joint pain	11
Muscle aches	8	Muscle aches	5
Headache	7	Headache	5
Muscle weakness	7	Muscle weakness	7
Sleep disturbances	6	Sleep disturbances	5
Loss of hair	4	Loss of hair	4
Rhinitis	4	Rhinitis	2
Paresthesia	3	Paresthesia	3
Back pain	3	Back pain	3
Pneumonia	2	Pneumonia	2
Tachycardia	2	Tachycardia	2
Deterioration of vision	2	Deterioration of vision	2
Concentration disorders	2	Concentration disorders	2
Deterioration of gait	2	Deterioration of gait	2
Skin problems	2	Skin problems	1
Congestion	2	Congestion	1
Gastric discomfort	2	Gastric discomfort	2
Psychological disorders, depression	2	Psychological disorders, depression	2
Deterioration of immunity	2	Deterioration of immunity	2
Impaired balance	1	Neuralgia *n. trigeminus*	1
Stiffness	1	Vertigo	1
Eye swelling	1	Chest pain	1
Neuralgia *n. trigeminus*	1	Weight loss	1
Vertigo	1	Hoarseness	1
Chest pain	1	Speech difficulties	1
Weight loss	1	Taste problems	1
Difficulty with urination, incontinence	1		
Hoarseness	1		
Speech difficulties	1		
Taste problems	1		

Table 3. Characteristics of physiotherapy program participants

Physiotherapy program	Gender	Age (years)	Disease duration (years)	Neurological disability (EDSS)	Comorbidities	Perceived symptom
O-PT	woman	51	6	1.5	none	Fatigue, weakness, thoracic pain
O-PT	woman	36	9	1.5	none	Fatigue, paresthesia, brain fog
O-PT	men	48	10	4.0	cardiovascular	Back pain, fatigue
Tele-PT	woman	33	3	2.0	none	Dyspnoea, anxiety, neck pain, headache
Tele-PT	woman	42	22	5.0	none	Fatigue, back and shoulder pain, voice disorders
Tele-PT	woman	37	20	2.0	none	Fatigue, dyspnea during physical activities, hoarseness

Note: O-PT – Outpatient physiotherapy program, Tele-PT – Telerehabilitation physiotherapy program, EDSS – Expanded Disability Status Scale (standard evaluation of neurological disability level, 0-3 is a minimal and mild neurological disability, EDSS 4 means that patient can walk without walking aid ≥500 m, EDSS 5 means that patient can walk without rest and walking aid ≥200 m)

Table 4. Evaluation of the physiotherapy program

	Baseline assessment	After completing rehabilitation	Mean change
Maximal respiratory excursion (axila level, in cm)	4.4 (SD 2)	5.6 (SD 2.3)	+1 cm
Maximal respiratory excursion (lower ribs level, in cm)	4.1 (SD 1.7)	6.1 (SD 2.2)	+2 cm
Maximal respiratory excursion (abdomen level, in cm)	3.9 (SD 1.7)	4.6 (SD 2.2)	+0.5 cm
Modified Fatigue Impact Scale (points)	35.5 (SD 8.5)	23 (SD 10.5)	–12
Subjective perceived symptoms	Fatigue, weakness, paresthesia, anxiety, dyspnoe, brain fog, back pain, neck pain, shoulder pain, voice disorders	Small reduction of pain (back pain, shoulder pain), improvement in breathing stereotype, less fatigued	

Discussion

Previous studies have described the possible persistence of health problems after SARS and MERS infection, and it has also been shown that COVID can be followed by persistent respiratory insufficiency, reduced aerobic capacity, and psychological problems ranging from anxiety to depression (Saladino et al., 2020). In addition, lower quality of life has also been described in up to 44% of patients after COVID infection (Carfi et al., 2020). Even some patients with mild symptoms of COVID infection reported delayed return to their job due to persisting symptoms such as fatigue, cough, and headache. These persisting symptoms were more frequent in older subjects and people with comorbidities (Tenforde et al., 2020). Because some symptoms (such as fatigue) are commonly present in people with chronic neurological diseases, a possible post-COVID syndrome is relatively more challenging to diagnose in patients with this disease. Still, it is good for healthcare workers to keep in mind that some of the new difficulties may be caused by the infectious disease (and not just the primary neurological disease). In our study of people with MS (n = 345), 22% reported post-COVID symptoms lasting 12 weeks or longer.

The most commonly reported symptom persisting after COVID-19 was fatigue (55%), followed by dyspnea (26%), and muscle and joint pain (18%). Similar results are described in other studies, which also report fatigue as the most common symptom (with an incidence of 13–90%), followed by dyspnea (10–70%) (Carfi et al., 2020; Ceban et al., 2022; Davis et al., 2023; Mikkelsen and Abramoff, 2022; Nehme et al., 2021). The presence of these symptoms can negatively affect the ability to participate in social activities. Fatigue is a common symptom accompanying neurological diseases such as MS. This MS fatigue can be caused by the primary disease (demyelination, inflammation in the central nervous system), or secondary to motor weakness, gait and coordination disorders, spasticity, urological problems interfering with sleep, or even as a side effect of medication (Kos et al., 2008). However, since fatigue often accompanies MS in the long term, we assume that the patients in the study are, to some extent, able to distinguish whether this is their "normal" MS fatigue or a new difficulty. Also, out of 40 people reporting fatigue, 33 reported other persistent post-COVID symptoms.

On the other hand, compared to other studies that reported a higher prevalence of cognitive impairment, depression, mood disorders, or sleep disturbances (Ceban et al., 2022; Morin et al., 2021; Wong et al., 2020; Ziauddeen et al., 2022), these difficulties were far less common in our cohort. Cognitive impairment (reduced working memory capacity, poorer ability to concentrate, etc.) and depression are also a common symptom in people with MS. Therefore, it is possible that the patients more likely attributed any poorer ability to concentrate to their primary neurological disease (Golan et al., 2018). It also appears that due to the higher rates of depression and anxiety in the MS population (compared to the healthy population), the COVID pandemic did not increase these as it did in the general population (Altieri et al., 2022).

More than half of the participants in our study who experienced persistent post-COVID-19 issues expressed interest in rehabilitation therapy. Rehabilitation therapies were offered to alleviate discomfort and enhance fitness, as supported by numerous studies (Goodwin et al., 2021). Various studies have also examined the impact of rehabilitation exercises on individuals with post-COVID syndrome (Ceban et al., 2023). In cases where post-COVID syndrome is complicated by post-exertional malaise, the exercise program must be individually tailored, avoiding routine progressive load increases and initial maximum load testing. Instead, the exercise difficulty is strictly personalised (Gloeckl et al., 2024). Despite these complexities, regular physical activity remains a valuable tool in managing post-COVID syndrome, as the syndrome's multifaceted nature makes it challenging to treat with a single pharmacotherapy. Regular physical activity helps regulate the immune response, providing both acute and long-term anti-inflammatory effects, as evidenced by decreased inflammatory markers such as C-reactive protein, and reduced production of interleukin-6 in muscles. Additionally, regular training promotes neuro and synaptic plasticity, mediated by the release of brain-derived neurotrophic factor (BDNF), positively impacting memory, sleep, and mood (Scurati et al., 2022). Therefore, in our small group of interested patients, we aimed to verify the feasibility of personalised exercise programs and the motivation for physical activity guided by a physiotherapist.

Our experience with a small group of people (n = 6) with MS highlights the effect of individualised physiotherapy on improving respiratory function and reducing fatigue. Although we did not implement a strict aerobic training protocol but instead focused on individual patient counselling and motivation, there was a notable improvement in fatigue, and overall, participants rated the program positively and expressed interest in continuing. This aligns with current recommendations for patients experiencing post-COVID fatigue, suggesting that long-term support and motivation tailored to individual capa-

bilities are more appropriate (Gloeckl et al., 2024). Based on our small sample, even the telerehabilitation variant of the exercise program showed effectiveness, consistent with previous studies that used telerehabilitation for post-COVID recovery, including aerobic training, resistance training, and breathing exercises (Seid et al., 2022).

Our study's small sample size is a major limitation, restricting the generalisability of our findings. Additionally, the reliance on subjective evaluations limits the robustness of the results. However, a significant strength of our study is that all patients who had an infection during the study period were directly contacted by healthcare professionals, unlike other studies that relied on online questionnaires to monitor the prevalence of post-COVID symptoms (Davis et al., 2021; Nehme et al., 2021). Despite these limitations, this pilot study provides valuable preliminary insights that can inform larger, more comprehensive research in the future. The observed positive effect of rehabilitation is not limited to individuals with neurological conditions such as MS; it may also benefit those with post-COVID syndrome, irrespective of other underlying diagnoses or pre-existing health conditions.

Conclusion

Knowledge of any persistent post-COVID difficulties can also help other health and social care professionals. Based on our findings, a considerable proportion of people with MS who underwent COVID-19 report symptoms consistent with post-COVID (long-COVID) syndrome. Therefore, we recommend that physicians and other health professionals consider this observation when evaluating symptoms in neurological patients. It would also be advisable to offer them the possibility to consult rehabilitation specialists or social workers. In cases of persistent difficulties, offering patients specialised physiotherapy interventions may be beneficial.

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Ethical aspects and conflict of interest
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