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# Practical Recommendations for Exercise Training in Patients with Long COVID with or without Post-exertional Malaise: A Best Practice Proposal

Rainer Gloeckl[1,2], Ralf H. Zwick[3], Ulrich Fürlinger[3], Tessa Schneeberger[1,2], Daniela Leitl[1,2], Inga Jarosch[1,2], Uta Behrends[4,5], Carmen Scheibenbogen[6] and Andreas Rembert Koczulla[1,2,7*]

**Abstract**

People with long COVID may suffer from a wide range of ongoing symptoms including fatigue, exertional dyspnea, reduced exercise performance, and others. In particular, impaired exercise performance is a condition that can be recovered in many people through an individualized physical exercise training program. However, clinical experience has shown that the presence of post-exertional malaise (PEM) is a significant barrier to physical exercise training in people with long COVID. Currently, there is no guideline or consensus available on how to apply exercise training in this cohort. Therefore, we conducted a literature review in the PubMed library using the following search terms: "COVID", "post-COVID", "long COVID" and "exercise" searching for studies from January 2020 to January 2024. Data from 46 trials were included. Exercise training regimes were very heterogeneous and none of these studies reported on the management of PEM in the context of an exercise training program. Based on the feedback from an additional survey that was answered by 14 international experts in the field of exercise training in long COVID, combined with the authors´ own extensive practical experience, a best practice proposal for exercise training recommendations has been developed. This proposal differentiates exercise procedures according to the presence of no, mild/moderate or severe PEM in people with long COVID. These recommendations may guide allied healthcare professionals worldwide in initiating and adjusting exercise training programs for people with long COVID, stratified according to the presence and severity of PEM.

**Key Points**

- Exercise training is considered as a crucial component of long COVID rehabilitation programs, but it may be complicated by the presence of post-exertional malaise.
- Currently, there is no consensus on the optimal training strategies for individuals with long COVID, with or without post-exertional malaise (PEM).
- We propose a best practice proposal for exercise training recommendations that distinguishes between exercise procedures based on the presence of no, mild/moderate or severe PEM in individuals with long COVID.

*Correspondence:
Andreas Rembert Koczulla
RKoczulla@schoen-klinik.de; koczulla@med.uni-marburg.de
Full list of author information is available at the end of the article

- Our best-practice proposal, which is based on scientific literature and extensive expert experience, can guide healthcare professionals in initiating and adjusting exercise training programs for individuals with long COVID, stratified according to the presence and severity of PEM.

**Keywords** Rehabilitation, Pulmonary rehabilitation, Post-COVID, COVID-19, SARS-CoV-2, Fatigue, Post exertional symptom exacerbation, PEM, PESE

## Background

According to the current NICE guideline, long COVID is a term used to describe signs and symptoms that persist or develop for more than four weeks after the acute phase of COVID-19 [1]. People with long COVID may experience a wide range of ongoing symptoms including fatigue, exertional dyspnea, psycho-neurological impairments, pain, reduced exercise performance, and others [2]. In particular, impaired exercise performance is a condition that can be recovered by an individualized physical exercise training program. Recent systematic reviews have shown that physical rehabilitation interventions are feasible, safe, and beneficial in people with long COVID by improving various physical, clinical, and psychological relevant outcomes [3]. In addition, long COVID-related symptoms such as exertional dyspnea or fatigue have been shown to improve following exercise training interventions [4]. However, a recent Cochrane review concluded that the available evidence has several methodological limitations that prevent the formulation of robust suggestions for exercise practice [5]. In particular, the presence of post-exertional malaise (PEM), a worsening of symptoms following physical, cognitive, or emotional activity that typically intensifies 12–48 h after an activity and lasts for days or even weeks [6], is a significant barrier to physical exercise training in long COVID. Up to now, there are no consistent exercise training recommendations for people with long COVID available. Therefore, we aimed to develop practical exercise training recommendations for individuals with long COVID, depending on the presence and severity of PEM.

## Methodological Aspects

Information on exercise training procedures in people with long COVID was derived from three different sources. First, a systematic literature search was performed in July 2023 and was updated in January 2024. The electronic search was carried out in the PubMed library using a search period from January 2020 to January 2024 and the following keywords: “COVID”, “Post-COVID”, “long COVID” and “exercise”. We included trials that used any kind of physical exercise training program in people with persistent symptoms related to COVID. There were no restrictions on study methodology (e.g. randomized, observational, retrospective etc.). As part of the study selection process, two independent researchers (R.G. and D.L.) screened the titles and the abstracts of the articles, reviewed the full text of all articles that met the inclusion criteria in the initial screening, and extracted data from the eligible studies (Fig. 1). Second, we developed a 48-question online survey on how exercise training is initiated and adapted in people with long COVID (Additional file 1). This survey was sent to international long COVID experts who have published studies on exercise training in people with long COVID to gather additional practical experiences beyond the reported details in publications. Thirdly, practical experiences from the four authors´ expert centers [7–9] after treating more than 3500 people with long COVID so far were also taken into consideration to create practical exercise training recommendations.

## Findings

The literature search revealed 46 original studies that investigated exercise training programs in individuals with long COVID (for extracted information on exercise training procedures see Table 1). Most studies performed 3–5 exercise training sessions per week for a period of 3–12 weeks. However, approaches to exercise prescription in the scientific literature were very heterogeneous. To determine training intensity during endurance training, various methods were employed. Ten studies used a percentage of peak heart rate, ranging from 40 to 85%. Eight studies used Borg exertion scores, ranging from 3 to 6 on the 0–10 point scale. Seven studies applied a percentage of peak work rate, ranging from 20 to 70%. Four studies used a percentage of heart rate reserve, ranging from 30 to 70%. Ten studies did not report how they determined intensity and seven studies did not apply endurance training (Table 1). Twenty of the 46 trials (43%) reported on the safety of exercise training in people with long COVID (without mentioning PEM). None of these trials documented any exercise-related adverse events. However, 57% of the included trials did not report the prevalence of exercise-related adverse events. Additionally, 14 experts (across 8 countries) also completed the survey. The responses from these experts were also very heterogeneous (e.g. endurance training intensity

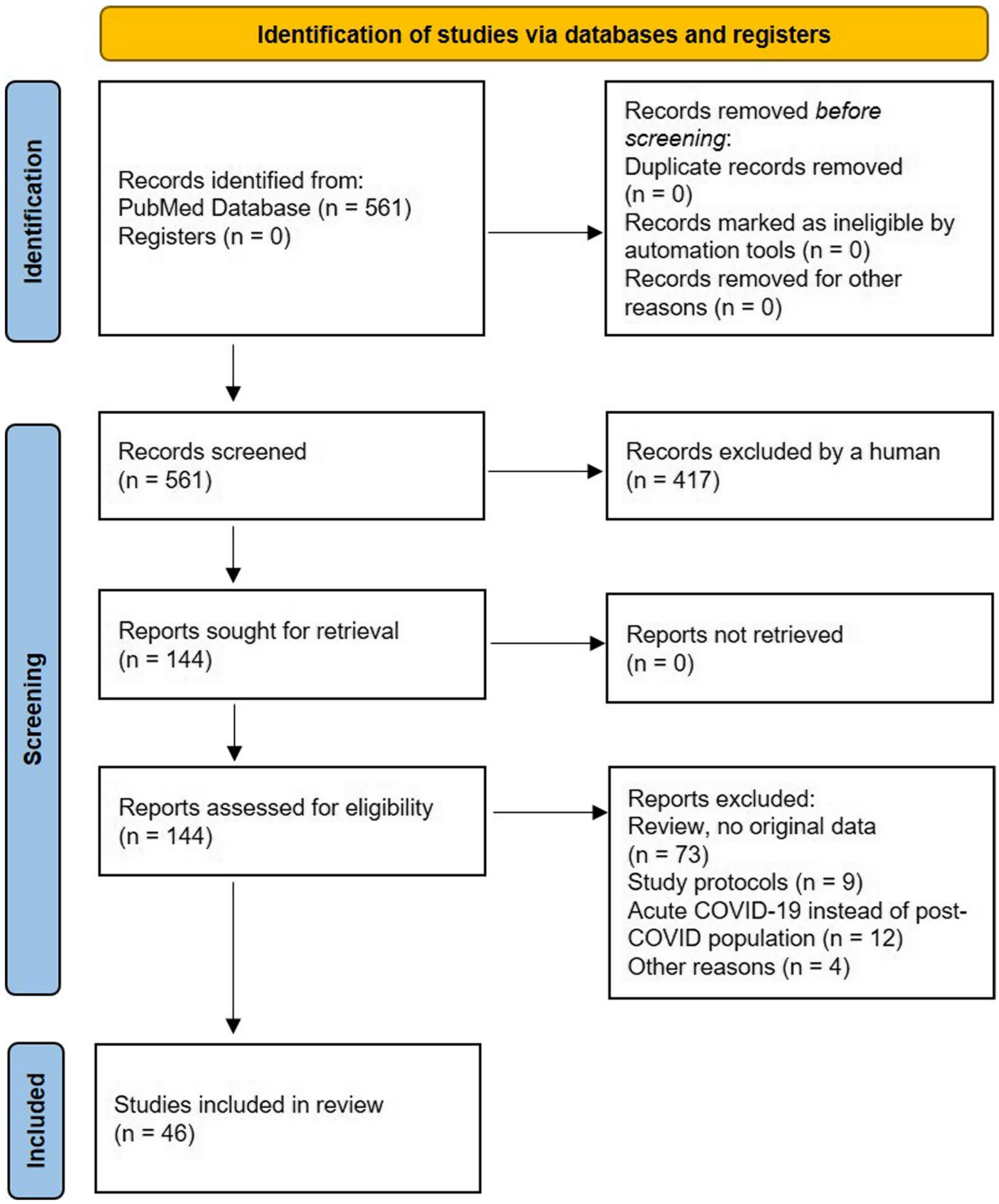


**Fig. 1** Literature search flow chart

ranged from 30 to 70% of peak heart rate or 30–60% of peak work rate). Based on the literature review, the expert survey, and the authors' own extensive experience, a proposal for practical exercise recommendations for people with long COVID stratified by the presence, frequency, severity, and duration of PEM was developed (Fig. 2).

Before starting an exercise program, a cardiac and pulmonary assessment should be performed to exclude potential contraindications to exercise training. Another crucial aspect before prescribing exercise training is to assess for PEM (by clinical interview and if suspected by using the DePaul Symptom Questionnaire-Post-Exertional Malaise, DSQ-PEM) [54]. PEM is also the cardinal symptom of myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) and therefore in long COVID cases with PEM, diagnostic ME/CFS criteria (Canadian Consensus or IOM criteria) should be checked [55, 56]. If there are no signs of PEM, a "conventional" exercise training program that combines moderate to intense endurance and strength training may be used. However, if people develop PEM after daily physical activity an individual activity management strategy known as pacing

**Table 1** Overview of exercise prescriptions in studies investigating exercise training programs in individuals with long COVID

| Study | Reference no. | Inclusion of people with long COVID and fatigue symptoms? | Assessing for PEM? | Endurance training modalities | | | | Strength training modalities | | IMT modalities | | Training-related serious adverse events |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Intensity | Continuous or interval training mode | Interval modality | Total duration [min] | Intensity | Sets and repetitions | Intensity | Duration | |
| Liu et al. 2020 | [10] | Not reported | Not reported | NA | | | | NA | | 60% PImax | 3×10 reps | Not reported |
| Gloeckl et al. 2021 | [7] | Yes | Not reported | 60–70% PWR | CT | – | 10–20 min | 15–20 RM | 3×15–20 reps | NA | | No adverse events |
| Daynes et al. 2021 | [11] | Yes | Not reported | Not reported | | – | Not reported | Not reported | | NA | | No adverse events |
| Abodonya et al. 2021 | [12] | Not reported | Not reported | NA | | | | NA | | 50% of MIP | 6×5 min | Not reported |
| Dalbosco-Salas et al. 2021 | [13] | Yes | Not reported | Borg 3–6 (0–10 scale) | CT | – | 20–30 min | NA | | NA | | Not reported |
| Martin et al. 2021 | [14] | Yes | Not reported | Borg 6 (0–10 scale) | CT | – | 30 min | 8–12 RM | 3×8–12 reps | NA | | No adverse events |
| Nambi et al. 2021 | [15] | Not reported | Not reported | 40–60% or 60–80% of peak HR | CT | – | 30 min | 10RM | 3×10 reps | NA | | Not reported |
| Stavrou et al. 2021 | [16] | Yes | Not reported | 75% of peak HR | CT | – | 50 min | Not reported | 2×12 reps | NA | | Not reported |
| Mohamed et al. 2021 | [17] | Yes | Not reported | 60–75% of peak HR | CT | – | 30 min | NA | | NA | | Not reported |
| Betschart et al. 2021 | [18] | Yes | Not reported | 20–30% PWR | CT | – | 30 min | 50–85% of 1RM | | 3×10–12 reps | NA | No adverse events |
| Hayden et al. 2021 | [19] | Yes | Not reported | Borg 4–6 (0–10 scale) | CT | – | 30–60 min | 12 RM | 3×12 reps | NA | | Not reported |
| Spielmanns et al. 2021 | [20] | Not reported | Not reported | 55–70% of peak HR | IT | 30–60 s | 10–30 min | 12 RM | 3×12 reps | NA | | Not reported |
| Udina et al. 2021 | [21] | Not reported | Not reported | Borg 3–5 (0–10 scale) | CT | – | 15 min | 30–80% of 1RM | 2×10 reps | NA | | Not reported |
| Zampogna et al. 2021 | [22] | Not reported | Not reported | Borg 4–5 (0–10 scale) | CT | – | 20–30 min | NA | | NA | | Not reported |
| Bouteleux et al. 2021 | [23] | Yes | Not reported | Not reported | – | – | – | Not reported | – | NA | | Not reported |
| Albu et al. 2021 | [24] | Yes | Not reported | Not reported | CT | – | 20–30 min | 12 RM | 3×12 reps | 30% PImax | 3×3 min | Not reported |
| Al Chikhanie et al. 2021 | [25] | Yes | Not reported | Not reported | – | – | – | Not reported | – | NA | | Not reported |

**Table 1** (continued)

| Study | Reference no. | Inclusion of people with long COVID and fatigue symptoms? | Assessing for PEM? | Endurance training modalities | | | | Strength training modalities | | IMT modalities | | Training-related serious adverse events |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Intensity | Continuous or interval training mode | Interval modality | Total duration [min] | Intensity | Sets and repetitions | Intensity | Duration | |
| Besnier et al. 2022 | [26] | Yes | Not reported | first ventilatory threshold (VT1) | CT | – | 30 min | 40% of 1RM | 3×10 reps | Not reported | 3×10 reps | Not reported |
| Jimeno-Almazan et al. 2022 | [27] | Yes | Not reported | 70–80% of HRR vs. 55–65% of HRR | IT | 4–6×3–5 min | 30 min | 50% of 1RM | 3×8 reps | NA | | No adverse events |
| Li et al. 2022 | [28] | Not reported | Not reported | 40–60% of HRR | CT | – | 45–60 min | NA | | NA | | No adverse events |
| Capin et al. 2022 | [29] | Not reported | Not reported | Not reported | IT | 10 s to 5 min | Not reported | 8 RM | 1×8 reps | NA | | No adverse events |
| McNarry et al. 2022 | [30] | Not reported | Not reported | NA | Not reported | – | NA | NA | | > 80% of PImax | 6×6 reps | Not reported |
| Nopp et al. 2022 | [8] | Yes | Not reported | 30–70% PWR | IT | 60 Sec | 20 min | 8–15RM | 3×8–15 reps | 80% PImax | 1×20 reps | No adverse events |
| Contreras-Briceno et al. 2022 | [31] | Yes | Not reported | 30–60% of HRR | CT | – | 40–60 min | NA | | NA | | Not reported |
| Hockele et al. 2022 | [32] | Not reported | Not reported | Not reported | CT | – | 20 min | „Light to intense" | 3×10 reps | 30% PImax | – | Not reported |
| Teixeira do Amaral et al. 2022 | [33] | Not reported | Not reported | Borg 11–13 (6–20 scale) | CT | – | 30 min | Borg 15–17 (6–20 scale) | 3×15–20 reps | NA | | No adverse events |
| Palau et al. 2022 | [34] | Not reported | Not reported | NA | | | | NA | | 30% PImax | 20 min | No adverse events |
| Estebanez-Pérez et al. 2022 | [35] | Yes | Not reported | Not reported | CT | – | 20–30 min | Not reported | 3×8–12 reps | NA | | No adverse events |
| Rutkowski et al. 2022 | [36] | Yes | Not reported | 60–80% of submaximal HR | CT | – | 30 min | Not reported | | NA | | Not reported |
| Corna et al. 2022 | [37] | Not reported | Not reported | 55–85% of peak HR | CT | – | 20 min | NA | | NA | | No adverse events |

**Table 1** (continued)

| Study | Reference no. | Inclusion of people with long COVID and fatigue symptoms? | Assessing for PEM? | Endurance training modalities | | | | Strength training modalities | | IMT modalities | | Training-related serious adverse events |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Intensity | Continuous or interval training mode | Interval modality | Total duration [min] | Intensity | Sets and repetitions | Intensity | Duration | |
| Vitacca et al. 2022 | [38] | Yes | Not reported | 70%PWR or 100% / 40% PWR | CT and IT | – | – | NA | | NA | | No adverse events |
| Asimakos et al. 2023 | [39] | Yes | Not reported | 50% PWR | IT | 30 Sec | 30 min | 60–70% of 1RM | 3 × 10 reps | NA | | No adverse events |
| Ostrowska et al. 2023 | [40] | Yes | Not reported | Not reported | – | – | Not reported | – | – | NA | | Not reported |
| Jimeno-Almazan et al. 2023 | [41] | Yes | Not reported | 70–80% of HRR vs. 55–65% of HRR | CT and IT | – | – | – | – | NA | | No adverse events |
| Spielmanns et al. 2023 | [42] | Not reported | Not reported | 55–70% of peak HR | IT | 30–60 s | 10–30 min | 12 RM | 3 × 12 reps | NA | | Not reported |
| Colas et al. 2023 | [43] | Not reported | PEM was exclusion criteria | Not reported | | | 90 min | Not reported | Not reported | NA | | Not reported |
| Alsharidah et al. 2023 | [44] | Not reported | Not reported | 60–80% of peak HR | CT | | 20–30 min | 10 RM | 3 × 10 reps | NA | | No adverse events |
| Ghasemi et al. 2023 | [45] | Not reported | Not reported | NA | | | NA | 65–75% of 1RM | 12–15 reps | NA | | Not reported |
| Minko et al. 2023 | [46] | Not reported | Not reported | Not reported | CT and IT | Not reported | 90 min | 70–85% of 1RM | 8–12 reps | NA | | Not reported |
| Espinoza-Bravo et al. 2023 | [47] | Yes | Not reported | Borg dyspnea score 4 (0–10 scale) | CT | | 25–45 min | Not reported | 2–3 × 10 reps | NA | | No adverse events |
| Mooren et al. 2023 | [48] | Yes | Not reported | 50% or 60%/30% PWR | CT and IT | 50–100 s | 18 min | NA | NA | NA | | Not reported |
| Del Corral et al. 2023 | [49] | Yes | Not reported | NA | | | NA | NA | NA | 20–80% PImax | 6–10 reps | No adverse events |
| Rodriguez-Blanco et al. 2023 | [50] | Yes | Not reported | NA | | | NA | Not reported | 12 reps | NA | | Not reported |

**Table 1** (continued)

| Study | Reference no. | Inclusion of people with long COVID and fatigue symptoms? | Assessing for PEM? | Endurance training modalities | | | | Strength training modalities | | IMT modalities | | Training-related serious adverse events |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Intensity | Continuous or interval training mode | Interval modality | Total duration [min] | Intensity | Sets and repetitions | Intensity | Duration | |
| Romanet et al. 2023 | [51] | Yes | Not reported | 60–70% of PWR or Borg dyspnea 4–6 (0–10 scale) | CT | | 15–60 min | Training until muscle fatigue | 4×6–12 reps | NA | | Not reported |
| Kerling et al. 2024 | [52] | Yes | Not reported | 60–75% of peak HR | CT | | | Not reported | Not reported | NA | | Not reported |
| Pietranis et al. 2024 | [53] | Yes | Not reported | 45–55% of peak HR or 70–80% of peak HR | CT and IT | 120–240 s | 15–45 min | Not reported | 8–12 reps | 45–80% of PImax | 6×6 reps | No adverse events |

6MWT—6-min walk test, CT—continuous endurance training, HR—heart rate, HRR—heart rate reserve, IMT—inspiratory muscle training, IT—interval endurance training, MIP—maximum inspiratory pressure, NA—not applied, PImax—maximal inspiratory pressure, PEM—post-exertional malaise, PWR—peak work rate, Ref—reference, RM—repetition maximum, reps—repetitions, sec—seconds

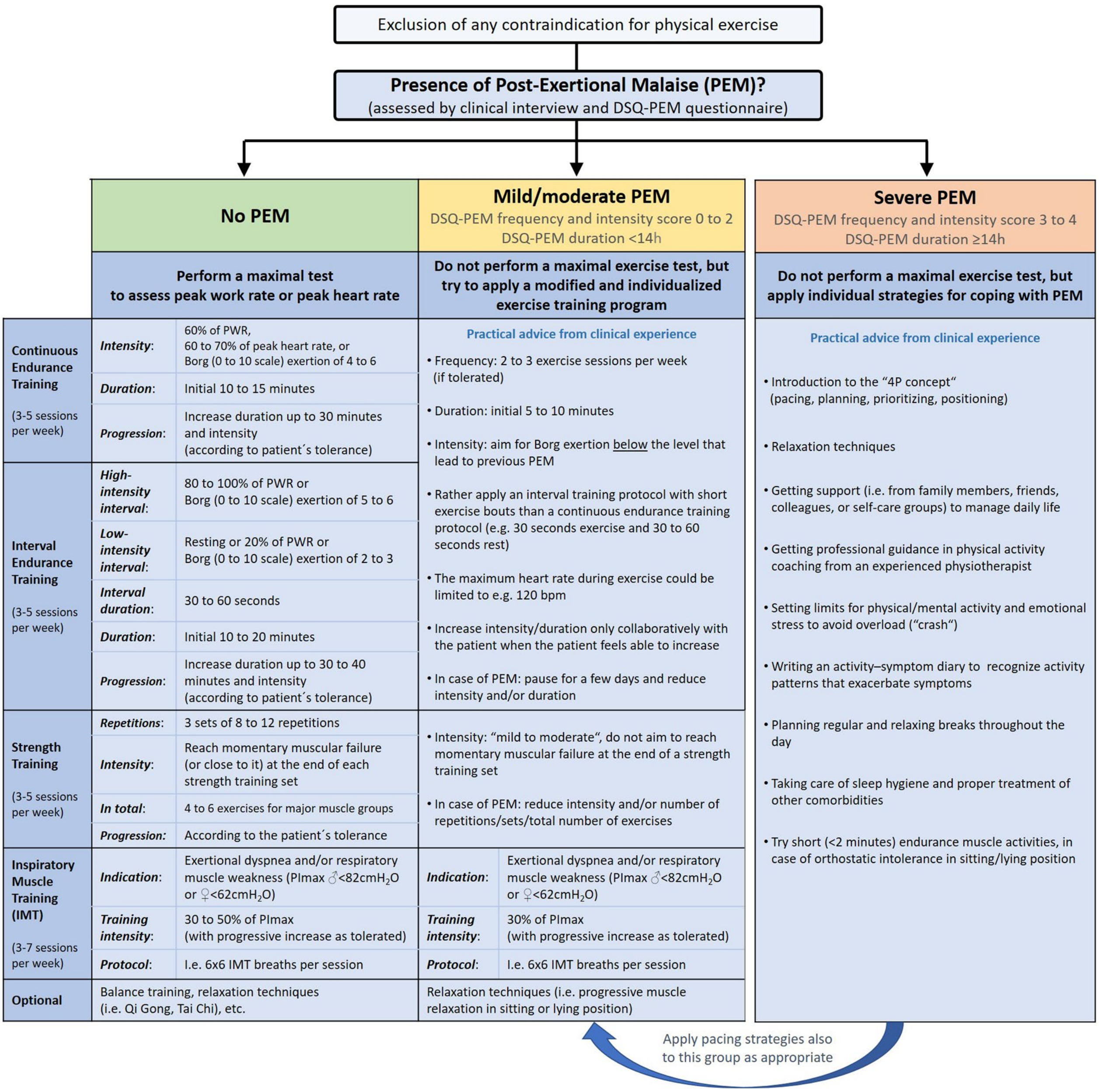


**Fig. 2** A best-practice proposal for exercise training recommendations in patients with long COVID (bpm = beats per minute, DSQ-PEM = DePaul Symptom Questionnaire-Post-Exertional Malaise, IMT = inspiratory muscle training, PImax = maximal inspiratory pressure, PWR = peak work rate)

or energy envelope maintenance [57] should be applied (Fig. 2).

## Discussion

We have presented best practice recommendations for exercise training in people with long COVID, based on a mixture of scientific literature, an international expert survey and our own practical experience. We believe that differentiating whether people with long COVID have a history of PEM and/or develop PEM after exercise is an important consideration concerning the adaptation of exercise training programs. If subjects with long COVID do not develop PEM, a fairly regular fitness training program of combined endurance and strength training could be applied as in healthy untrained individuals. If people develop mild to moderate PEM, a modified exercise training program might be used (depending on individual tolerance). For people with long COVID and severe PEM, the focus should be on pacing strategies similar to those used in patients with ME/CFS.

In January 2023, the World Health Organization (WHO) suggested that people with long COVID and significant impact on everyday functioning should be referred to rehabilitation services [58, 59]. There was also a recommendation that the presence of PEM will require interventions to be modified without mentioning further details [58]. The WHO, as well as the Cochrane Institute, concluded that there is currently no direct evidence of the effectiveness of rehabilitation in the subgroup of people with long COVID and PEM [58, 60]. Our literature review supports these statements since none of the 46 studies specifically reported on PEM (Table 1). However, 12 out of 14 survey participants stated that long COVID individuals should be screened for PEM.

One condition in which PEM plays an important role is ME/CFS. However, the updated 2021 NICE guideline for ME/CFS no longer recommends graded exercise therapy (GET) [61] anymore (compared to the previous guideline version). GET is defined as "first establishing an individual's baseline of achievable exercise or physical activity, then making fixed incremental increases in the time spent being physically active including supervision by a physiotherapist in a ME/CFS specialist team" [6]. Up to now, studies that investigated GET as an intervention in patients with ME/CFS used also very heterogeneous training approaches (i.e. intensity at 50% of peak heart rate, at 70% from the anaerobic threshold, or just the advice to "start at a level that patients think they can do") [62]. This paradigm change in the NICE guideline regarding GET evolved also into a controversial debate on the role of exercise training [63–65]. However, it is regarded as common sense that in patients with PEM, activity management strategies must be carefully customized to reflect the individual needs and limits of each individual [66, 67]. We therefore propose an individualized and symptom-titrated approach rather than GET with a fixed progression of the exercise load in patients with mild/moderate PEM. Our recommendation for pacing (energy envelope maintenance) in severe PEM is based on a recent UK study showing that a structured pacing protocol significantly reduced the incidence of PEM and improved the general condition of patients with long COVID [68]. Screening and scoring PEM was suggested to be a useful procedure for assessing the tolerance of certain interventions in patients with chronic fatigue [69]. Pacing was shown to be associated with better outcomes in the management of people with long COVID [70] and may be especially beneficial for individuals with higher available energy who are pushing themselves beyond their energy limitations [57]. Since people with mild to moderate PEM are at risk of developing more frequent, severe, and long-lasting PEM triggered by daily activities, they need to be carefully guided to remain as active as possible while avoiding "crashes" resulting from too much exertion [57].

One limitation of our literature review is that we used only a single database (PubMed). However, our literature review was not designed to provide evidence of effectiveness. Rather, we wanted to compare approaches to exercise training in people with long COVID, and these were found to be very heterogeneous. Another limitation of our proposal is that evidence of the efficacy of our recommendations in people with long COVID is limited so far. Moreover, different recommendations might be necessary for children with long COVID. However, several individual components of our practical recommendations have already been investigated in specific clinical trials and were found to be beneficial and safe in many people with long COVID (e.g. interval endurance training [38] or inspiratory muscle training [30]).

## Conclusion

In our best-practice proposal, we merged the scientific literature and international expert experiences to propose a more homogeneous exercise training concept in people with long COVID, stratified depending on the presence and severity of PEM. These recommendations may guide allied healthcare professionals worldwide to initiate and adjust exercise training programs in long COVID.

### Abbreviations

| | |
|---|---|
| 6MWT | 6-Minute walk test |
| CT | Continuous endurance training |
| DSQ-PEM | DePaul Symptom Questionnaire-Post-Exertional Malaise |
| HR | Heart rate |
| HRR | Heart rate reserve |
| IMT | Inspiratory muscle training |
| IT | Interval endurance training |
| ME/CFS | Myalgic encephalomyelitis/chronic fatigue syndrome |
| NA | Not applicable |
| PImax | Maximal inspiratory pressure |
| PEM | Post-exertional malaise |
| PWR | Peak work rate |
| Reps | Repetitions |
| Ref | References |
| RM | Repetition maximum |
| Sec | Seconds |
| WHO | World Health Organization |

## Supplementary Information

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**Additional file 1.** Supplementary Material Appendix S1.

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**Author Contributions**
All authors contributed to the study conception and design. Data collection for the review and the survey were performed by RG. Data interpretation was done by all authors. The first draft of the manuscript was written by RG. All authors commented on subsequent versions of the manuscript. All authors read and approved the final manuscript.

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**Availability of Data and Materials**
All data generated during the current study (systematic review and online survey) are available in the manuscript and/or the online supplement.

## Declarations

**Ethics Approval and Consent to Participate**
Not applicable.

**Consent for Publication**
Not applicable.

**Competing Interests**
The authors declare no competing interests.

**Author details**
[1]Department of Pulmonary Rehabilitation, Philipps-University of Marburg, Marburg, Germany. [2]Institute for Pulmonary Rehabilitation Research, Schoen Klinik Berchtesgadener Land, Schoenau am Koenigssee, Germany. [3]Therme Wien Med, Ludwig Boltzmann Institute for Rehabilitation Research, Vienna, Austria. [4]Childrens' Hospital, School of Medicine, Technical University of Munich, Munich, Germany. [5]German Center for Infection Research (DZIF), Berlin, Germany. [6]Institute of Medical Immunology, Charité - Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt Universität Zu Berlin, Berlin, Germany. [7]Teaching Hospital, Paracelsus Medical University Salzburg, Salzburg, Austria.

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