Respir. Med and Res 83 (2023) 100991

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com

Short communication

Effectiveness of a home-based pulmonary rehabilitation programme in people recovering from a severe and critically COVID-19 infection

Sarah Gephine[a,b], Malcolm Lemyze[c], Philippe Pauquet[c], Olivier Le Rouzic[d], Stéphanie Fry[d], Cécile Chenivesse[d], Jean-Marie Grosbois[b,*]

[a] *EA 7369 - URePSSS - Unité de Recherche Pluridisciplinaire Sport Santé Société, University Lille, University Artois, University Littoral Côte d'Opale, Lille 59000, France*
[b] *FormAction Santé, Rue de Pietralunga, Pérenchies 59840, France*
[c] *CH Arras, Service de Réanimation et Unité de Sevrage Intensif et Réhabilitation Post-Réanimation, Arras 62000, France*
[d] *Centre de Référence Constitutif des Maladies Pulmonaires Rares, CHU Lille, Service de Pneumologie et Immuno-Allergologie, Lille 59000, France*

ARTICLE INFO

Article history:
Received 17 June 2022
Accepted 2 January 2023
Available online 9 January 2023

Keywords:
Coronavirus
Pulmonary rehabilitation
Intensive care
Exercise tolerance
Home-based sessions

Thousands of French individuals who have been discharged after contracting coronavirus 2019 disease (COVID-19) have to live with the acute consequences of artificial ventilation and prolonged inactivity, amongst which some of them will experience long-term impairments including chronic fatigue, breathlessness, cognitive symptoms and muscle weakness [1].

Multidisciplinary interventions, such as pulmonary rehabilitation (PR) [2], have been strongly recommended by international clinical experts to manage the long-term post-COVID syndrome [3]. Previous studies have demonstrated the effectiveness of at least 3-week inpatient PR interventions for improving the pulmonary function, health-related quality of life and physical, cognitive and psychosocial status of mild to critically ill post-COVID patients [4–6]. Given that traditional PR seems feasible, safe and effective for this population, other options such as home-based PR or telerehabilitation helping to relieve the already overloaded French health care system, need to be documented. Therefore, with this real-life study we evaluated the effectiveness of a home-based PR programme conducted in individuals recovering from the acute phase of a severe COVID-19 infection.

Data of all consecutive patients who had been addressed to the home-based PR programme between April 2020 and October 2021 after contracting a critical or severe COVID-19 infection, were prospectively collected in a computerized medical record and retrospectively analysed. Participants were referred to the intervention by an intensive care unit (ICU, Arras Hospital, France) or by nine pneumology units (Hospitals in North of France). All the individuals coming from the ICU were invasively ventilated (with or without a tracheotomy). Detailed regarding the severity of their acute infection can be found elsewhere [7]. These individuals received early inpatient post-intensive care rehabilitation (early mobilization/bedside physiotherapy and education for 26 (6 to 84) days on average) before being discharge at home. This early individualized rehabilitation programme was performed by the trained ICU team which is equipped with a specific physical training room including the required facility for monitoring and training vulnerable critically ill patients [7]. Individuals coming from the pneumology units did not received maximal oxygen flow neither early inpatient PR programme before being discharge.

The home-based PR was offered by a private company (*FormAction Santé*) that has been offering this model of intervention for people with chronic respiratory disease for over a decade [8,9]. Details regarding the ethical approval (CEPRO 2021–054), informed consent of participants, and PR programme can be found elsewhere. Briefly, the personalized PR programme consisted of a weekly supervised 90 min home session, during 4 to 8 weeks according to the patient's needs. Physical training, educational, motivational and self-management plans were designed and implemented through a collaborative

* Corresponding author.
E-mail address: jmgrosbois@formactionsante.com (J.-M. Grosbois).

https://doi.org/10.1016/j.resmer.2023.100991

process. Apart from the weekly supervised visit, participants were expected to perform a personalised physical training and self-management plan the rest of the week.

Dyspnoea (modified medical research council, mMRC), fatigue (fatigue assessment scale, FAS), anxiety and depression (hospital anxiety and depression scale, HAD), health-related quality of life (visual-analogue scale of the EQ-5D-3 L questionnaire, VAS) and physical condition (6-minute stepper test, 6MST; 5-time sit-to-stand, 5STS; handgrip force) were assessed at the beginning (M0) and at the end of PR (M2).

Mean±SD and proportions were used for descriptive statistics, as appropriate. Changes over time were analysed with paired t-tests and two-way repeated measure ANOVA (between group comparison). Missing data were imputed using an EM approach. The level of significance was set at $p<0.05$.

46 participants were enroled into the home-based programme (17 patients post-ICU, hospitalised for 34 (8 to 150) days and 29 post-pneumology units hospitalised for 18 (2 to 90) days). The majority of them (female, 50%) were 60±13 years old, suffering from obesity (IMC, 31±8 kg/m^2) and current smokers (54%). Hypertension (37%), diabetes (24%) and COPD (24%) were common comorbidities. At admission, 20%, 24% and 11% of the patients required long-term oxygen therapy, oxygen during exercise and non-invasive ventilation, respectively. With an exception for the anxiety symptoms score (post-ICU, 7.4 ± 2.9 points and post-pneumology units, 9.9 ± 4.9 points, p = 0.034) and the Charlson comorbidity index (post-ICU, 3.9 ± 2.2 points and post-pneumology units, 2.7 ± 2.1 points, p = 0.042), there was no difference in baseline characteristics or assessments between participants coming from the ICU and those coming from the pneumology units.

Seven (15.2%) patients did not conclude PR (two deaths (multiple pathologies and immunocompromised), three exacerbations, one ankle pain, one new COVID-19 infection). Amongst the individuals who finished the programme, all the participants coming from the ICU (16 patients) received 6 to 8 supervised home sessions, while 18 (78%) participants and 5 (22%) participants coming from the pneumology units received 6 to 8 and 4 to 5 supervised home sessions, respectively. All the outcomes were improved by PR in both groups ($p<0.001$) (Table 1). With an exception for the health-related quality of life (p = 0.040), comparisons showed similar time courses for all outcomes between the post ICU and post-pneumology units individuals.

Supporting previous studies offering inpatient PR [4,5], we report the effectiveness of 4 to 8 weeks of home-based PR for improving dyspnoea, fatigue, anxiety and depressive symptoms, exercise tolerance, functional capacity and muscle weakness in COVID-19 survivors. The strengths of this study were (i) to offer home-based sessions by a trained healthcare PR team when inpatient interventions were overburdened or closed, and (ii) to included both people recovering from a critical or severe COVID-19 infection coming from the ICU or pneumology units. Home-based intervention combined with telerehabilitation sessions could be a suitable option for taking care of as many as possible of COVID-19 survivors [10]. However, caution is warranting when interpreting these results because of the retrospective nature of the study and its small sample size. Moreover, the number of deaths and exacerbations during PR was higher than what we usually report in patients with chronic respiratory disease (present study: 11% vs previous studies: 4% and 2,5%, respectively [9,11]). This will have to be considered in future studies in patients recovering from critical or severe COVID-19 infection.

In a recent multicenter study 74%, 26% and 16% of the individuals were still reporting physical, mental and cognitive symptoms, respectively, one year following ICU treatment for COVID-19 [1], showing the importance of offering PR interventions to COVID-19 survivors. Except for the anxiety symptom, the baseline characteristics and assessments were similar between our two groups. The early inpatient rehabilitation performed an average for 26 days in the group of patients coming from the ICU could explain this result. Although the short- and long-term effects of early rehabilitation during ICU stay are still discussed [12], we showed that COVID-19 survivors benefited from combining early rehabilitation during the ICU stay and 6 to 8 home-based sessions after being discharge. Another explanation could be that since the ICU were overburdened, pneumology units could have received patients with the same acute infection severity. Unfortunately, we do not have detailed information regarding this point. Patients coming from the pneumology units did not receive an early inpatient rehabilitation programme which is a limitation of the present study. However, at the time of the inclusion of the participants, hospital-based PR units were closed and/or had not yet developed specific interventions for patients with COVID-19 infection.

One could argue that performing only 4 to 8 supervised sessions are not sufficient to obtain benefits [2]. Nevertheless, we reported statistically significant improvements after PR that seemed also to be clinically relevant according to the minimal clinically important difference reported in patients with chronic respiratory disease (for example, 40 strokes for the 6MST [13], 1.5 points for the anxiety and depressive symptoms [14], 1.7 s for the 5STS [15]). Therefore, the optimized number of PR sessions for individuals recovering from COVID-19 (but also for patients with chronic respiratory disease) needs to be discussed as it might be smaller than the current international recommendations of 20–25 sessions.

Table 1
Effects of the home-based pulmonary rehabilitation programme according to the hospitalisation units.

Outcomes	Total group		Post ICU		Post- pneumology units	
	M2 score	**ΔM2-M0** Estimates (95% CI)	**M2** score	**ΔM2-M0** Estimates (95% CI)	**M2** score	**ΔM2-M0** Estimates (95% CI)
mMRC, score (0–4)	1.3 ± 1.0	−1.2 (−1.4 to −1.0)	1.0 ± 1.1	−1.3 (−1.6 to −1.0)	1.7 ± 1.0	−1.0 (−1.2 to −0.8)
FAS, score (10–50)	21.6 ± 7.8	−5.9 (−7.6 to −4.3)	18.5 ± 5.9	−6.4 (−7.9 to −4.8)	23.9 ± 8.9	−5.0 (−6.7 to −3.3)
HAD-Anxiety score (0–21)	6.8 ± 3.9	−2.3 (−3.3 to −1.4)	5.8 ± 3.7	−1.6 (−2.8 to −0.5)	7.1 ± 3.9	−2.8 (−3.6 to −2.0)
HAD-Depression, score (0–21)	3.3 ± 4.0	−2.7 (−3.7 to −1.7)	2.6 ± 3.8	−2.9 (−4.1 to −1.8)	4.0 ± 3.5	−2.4 (−3.2 to −1.5)
VAS, score (0–100)	58.1 ± 16.8	18.4 (9.5 to 22.8)	53.7 ± 16.3	21.8 (12.5 to 31.1)*	60.2 ± 18.3	12.2 (5.8 to 18.7)
6MST, strokes	542 ± 171	136 (100 to 171)	582 ± 220	165 (131 to 199)	532 ± 105	132 (93 to 170)
5STS, seconds	8.9 ± 1.8	−2.4 (−3.0 to −1.8)	8.8 ± 1.7	−2.6 (−3.2 to −1.9)	9.2 ± 1.9	−2.3 (−2.9 to −1.7)
Handgrip, kg	29.0 ± 8.4	3.7 (2.3 to 5.0)	31.2 ± 9.1	3.8 (3.0 to 4.7)	28.4 ± 8.3	4.6 (2.9 to 6.2)

M2, end of PR programme; Δ, delta M2-M0; mMRC, modified medical research council dyspnoea scale; FAS, fatigue assessment scale; HAD, hospital anxiety and depression scale; VAS, visual-analogue scale of the EQ-5D-3 L questionnaire; 6MST, 6-minute stepper test; 5STS, five times sit-to-stand test. M2, results are presented as mean ± SD. ΔM2-M1, missing data were imputed using an EM approach and results are presented as estimates (95% confidence interval). All the outcomes were improved at M2 compared to M1 in both groups. With an exception for the health-related quality of life (VAS, score), two-way repeated measure ANOVA showed similar time courses for all outcomes between the post ICU and post-pneumology units individuals.

* p = 0.04.

Because of the design of this study, a control group of survivors of COVID-19 not receiving home-based PR could not be recruited. We report here similar or even higher improvements to those observed in our previous study using the same intervention in frail patients with chronic obstructive pulmonary disease [16]. This finding is supported by a previous controlled study [17]. The individuals own abilities to recover from a COVID-19 infection without intervention, may also be involved in the present positive results.

Author contribution

SG and JMG contributed to the study design, the recruitment of patients, the acquisition and analysis of the data, the interpretation of the results, and the redaction of the manuscript. ML, PP, OLR, SF and CC contributed to the recruitment of patients, and the redaction of the manuscript. All authors approved the final version of the manuscript.

Disclosure

JMG reports non-financial support unrelated to the submitted work from AstraZeneca, Boehringer Ingelheim, Chiesi, CSL Behring, GlaxoSmithKlein and Novartis. **OLR** reports personal fees and/or non-financial support from AstraZeneca, Boehringer Ingelheim, Chiesi, Lilly and Novartis, non-financial support from GlaxoSmithKline, Mayoli, MSD, Pfizer, PulmonX, Santelys association, Vertex, Vitalaire and Zambon, outside the submitted work. **CC** reports personal fees and non-financial support unrelated to the submitted work from ALK-Abello, AstraZeneca, Boehringer Ingelheim, Chiesi, GlaxoSmithKlein, MEDA Pharma, Medexact, Novartis, Pierre Fabre, Pfizer, Roche, Sanofi, Santélys, and TEVA. None of the others authors have any conflict of interest to disclose.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank the members of the rehabilitation team: Sophie Duriez, Géraldine Gabet, Mathieu Grosbois, Marjorie Lambinet, Maité Masson, Valentine Opsomer, Aurore Taccoen, Gaelle Tywoniuk, Florence Urbain, Sandrine Vanexem, and Virginie Wauquier.

Funding

Home-based PR were financially supported by Adair, Aeris Santé, Bastide, Elivie, France Oxygène, Homeperf, LVL, Medopale, NorOx, Santélys, SOS Oxygène, Sysmed, VentilHome, VitalAire, and ARS Hauts-de-France. The funders played no role in the design, conduct or reporting of this study.

References

[1] Heesakkers H, van der Hoeven JG, Corsten S, Janssen I, Ewalds E, Simons KS, Westerhof B, Rettig TCD, Jacobs C, van Santen S, Slooter AJC, van der Woude MCE, van den Boogaard M, Zegers M. Clinical outcomes among patients with 1-year survival following intensive care unit treatment for COVID-19. JAMA 2022;327(6):559–65.
[2] Spruit MA, Singh SJ, Garvey C. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation. Am J Respir Crit Care Med 2013;188(8):e13–64.
[3] Spruit MA, Holland AE, Singh SJ, Tonia T, Wilson KC, Troosters T. COVID-19: interim guidance on rehabilitation in the hospital and post-hospital phase from a European respiratory society and American thoracic society-coordinated international task force. Eur Respir J 2020.
[4] Chen H, Shi H, Liu X, Sun T, Wu J, Liu Z. Effect of pulmonary rehabilitation for patients with post-COVID-19: a systematic review and meta-analysis. Front Med 2022;9:837420 (Lausanne).
[5] Soril LJJ, Damant RW, Lam GY, Smith MP, Weatherald J, Bourbeau J, Hernandez P, Stickland MK. The effectiveness of pulmonary rehabilitation for post-COVID symptoms: a rapid review of the literature. Respir Med 2022;195:106782.
[6] Demoule A, Morawiec E, Decavele M, Ohayon R, Malrin R, Galarza-Jimenez MA, Laveneziana P, Morelot-Panzini C, Similowski T, De Rycke Y, Gonzalez-Bermejo J. Health-related quality of life of COVID-19 two and 12 months after intensive care unit admission. Ann Intensive Care 2022;12(1):16.
[7] Lemyze M, Komorowski M, Mallat J, Arumadura C, Pauquet P, Kos A, Granier M, Grosbois JM. Early intensive physical rehabilitation combined with a protocolized decannulation process in tracheostomized survivors from severe COVID-19 pneumonia with chronic critical illness. J Clin Med 2022;11(13).
[8] Grosbois JM, Gicquello A, Langlois C, Le Rouzic O, Bart F, Wallaert B, Chenivesse C. Long-term evaluation of home-based pulmonary rehabilitation in patients with COPD. Int J Chron Obstruct Pulmon Dis 2015;10:2037–44.
[9] Grosbois JM, Gephine S, Kyheng M, Henguelle J, Le Rouzic O, Saey D, Maltais F, Chenivesse C. Physical and affective components of dyspnoea are improved by pulmonary rehabilitation in COPD. BMJ Open Respir Res 2022;9(1).
[10] Lugo-Agudelo LH, Cruz Sarmiento KM, Spir Brunal MA, Velasquez Correa JC, Posada Borrero AM, Fernanda Mesa Franco L, Di Dio Castagna Ianini R, Ramirez Perez Lis PA, Velez CM, Patino Lugo DF, Gutenbrunner C. Adaptations for rehabilitation services during the COVID-19 pandemic proposed by scientific organizations and rehabilitation professionals. J Rehabil Med 2021;53(9):jrm00228.
[11] Coquart JB, Le Rouzic O, Racil G, Wallaert B, Grosbois JM. Real-life feasibility and effectiveness of home-based pulmonary rehabilitation in chronic obstructive pulmonary disease requiring medical equipment. Int J Chron Obstruct Pulmon Dis 2017;12:3549–56.
[12] Castro-Avila AC, Seron P, Fan E, Gaete M, Mickan S. Effect of early rehabilitation during intensive care unit stay on functional status: systematic review and meta-analysis. PLoS One 2015;10(7):e0130722.
[13] Pichon R, Couturaud F, Mialon P, Le Ber-Moy C, Peran L, Lochon C, Nowak E, Beaumont M. Responsiveness and minimally important difference of the 6-minute stepper test in patients with chronic obstructive pulmonary disease. Respiration 2016;91(5):367–73.
[14] Puhan MA, Frey M, Buchi S, Schunemann HJ. The minimal important difference of the hospital anxiety and depression scale in patients with chronic obstructive pulmonary disease. Health Qual Life Outcomes 2008;6:46.
[15] Jones SE, Kon SS, Canavan JL, Patel MS, Clark AL, Nolan CM, Polkey MI, Man WD. The five-repetition sit-to-stand test as a functional outcome measure in COPD. Thorax 2013;68(11):1015–20.
[16] Gephine S, Saey D, Grosbois JM, Maltais F, Mucci P. Home-based pulmonary rehabilitation is effective in frail COPD patients with chronic respiratory failure. Chronic Obstr Pulm Dis 2021.
[17] Busching G, Zhang Z, Schmid JP, Sigrist T, Khatami R. Effectiveness of pulmonary rehabilitation in severe and critically Ill COVID-19 patients: a controlled study. Int J Environ Res Public Health 2021;18(17).