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a pilot study

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SHORT COMMUNICATION

FEASIBILITY OF INSPIRATORY MUSCLE TRAINING FOR PATIENTS WITH PERSISTENT DYSPNOEA AFTER COVID-19 INFECTION: A PILOT STUDY

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***Objective*: This study investigates the feasibility of delivering inspiratory muscle training as part of the physical therapy treatment for patients with post-COVID dyspnoea.**
***Design*: Mixed-methods pilot study.**
***Subjects/patients*: Patients with complaints of dyspnoea after COVID-19 infection and their physical therapists.**
***Methods*: The Amsterdam University of Applied Sciences and the Amsterdam University Medical Centers conducted this study. Participants performed daily inspiratory muscle training at home for 6 weeks, consisting of 30 repetitions against a pre-set resistance. The primary outcome was feasibility assessed as acceptability, safety, adherence and patient- and professional experience obtained through diaries and semi-structured interviews. The secondary outcome was maximal inspiratory pressure.**
***Results*: Sixteen patients participated. Nine patients and 2 physical therapists partook in semi-structured interviews. Two patients dropped out before initiating the training. Adherence was 73.7%, and no adverse events occurred. Protocol deviations occurred in 29.7% of the sessions. Maximal inspiratory pressure changed from 84.7% of predicted at baseline to 111.3% at follow-up. Qualitative analysis identified barriers to training: 'Getting acquainted with the training material' and 'Finding the right schedule'. Facilitators were: 'Support from physical therapists' and 'Experiencing improvements'.**
***Conclusion*: Delivering inspiratory muscle training to patients with post-COVID dyspnoea seems feasible. Patients valued the simplicity of the intervention and reported perceived improvements. However, the intervention should be carefully supervised, and training parameters adjusted to individual needs and capacity.**

LAY ABSTRACT

Many people who have recovered from a COVID-19 infection develop persistent shortness of breath, fatigue and difficulties with memories, learning new things or making decisions. This condition affects their daily life and is called post-COVID syndrome. *Inspiratory muscle training* is a technique that aims to help people to breathe more easily by strengthening and improving the coordination of breathing muscles. We undertook this study to determine if performing such training was possible for these patients. We interviewed 2 physiotherapists who provided the training and 9 of their patients. In addition, we looked into the diaries 16 patients kept about their training to learn about their experiences or unexpected (medical) problems they might have had with the training. We found that the training seemed reasonable since patients and their physiotherapists found it simple, and no negative experiences happened. However, patients said it helped if the physiotherapist supervised them during the training.

Key words: COVID-19; dyspnoea; maximal inspiratory pressures; physical therapy modalities.

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Patients recovering from coronavirus disease 2019 (COVID-19) often experience prolonged symptoms such as dyspnoea, fatigue, cognitive impairment and exercise intolerance, collectively known as post-COVID syndrome (1, 2). Dyspnoea is one of the most debilitating symptoms of post-COVID syndrome, associated with poorer quality of life (QoL) and potentially caused by an autonomic dysfunction resulting in impaired breathing coordination and hyperventilation (3, 4).

Inspiratory muscle training (IMT) effectively decreases dyspnoea in patients with chronic obstructive pulmonary disease and in patients who have undergone abdominal or thoracic surgery and can potentially improve autonomic control (5–7). In addition, a recent study evaluating the effects of IMT in patients recovering from COVID-19 found that IMT could reduce dyspnoea in these patients (8). During IMT, the individual breathes through a handheld device, restricting airflow to stimulate and strengthen inspiratory muscles. Such training can be performed independently at home. Furthermore, home-based exercise training programs have been shown to improve health outcomes in other respiratory conditions and offer people for whom traveling to a rehabilitation centre or physical therapy (PT) practice is difficult the possibility to rehabilitate from home (9–11).

In the Netherlands, the Royal Dutch Society for Physiotherapy (KNGF) recommends IMT as part of the treatment for patients with persistent dyspnoea after COVID-19. However, for COVID treatment guidelines, data on the feasibility of IMT and recommendations for frequency and intensity of the training are lacking. Therefore, this study investigated the feasibility of a home-based IMT training protocol as part of the COVID-19 PT program.

METHODS

The Amsterdam University of Applied Sciences and the Amsterdam University Medical Centers (AUMC, location AMC) conducted a mixed-method pilot study in collaboration with a primary care PT clinic delivering post-COVID rehabilitation interventions according to Dutch clinical practice recommendations. The Medical Ethics Committee of the AUMC provided a waiver for this study (METC W21_373 #21.413).

Patients and their PTs were participants in this study. Patients were eligible if they: (i) had dyspnoea, assessed by PTs with the Medical Research Council dyspnoea scale (12) as one of the main complaints of post-COVID syndrome, (ii) were 18 years or older and (iii) were able to communicate in Dutch or English. Eligible patients were informed of the study by the PTs and contacted by the researchers if they provided consent for participation.

Intervention

IMT was performed with the Powerbreathe© Medic, a threshold IMT device manufactured by POWERbreathe International Limited. The intervention followed a protocol similar to the one used in a published trial investigating the effect of IMT on respiratory muscle strength after lung cancer surgery (13). Patients were seated upright with relaxed shoulders and feet flat on the ground and performed 30 inhalations against a pre-set resistance once daily (Fig. 1). PTs regularly reviewed the performance of the patients and could adjust the protocol if they deemed it necessary. The starting intensity was set at 30% of the maximal inspiratory pressure (MIP) and could be modified per the PT's instruction. Patients performed the training at home for 6 weeks. All patients received additional weekly PT interventions aimed at increasing exercise capacity.

Data collection

Data on the primary outcome – feasibility – assessed as acceptability, safety, adherence and patient- and professional experience were retrospectively collected through patient-reported information from anonymized diaries and (telephonic) interviews. Data on the primary outcome were collected after the 6-week intervention was completed due to the retrospective character of our study. Patient diaries included data on the total number of completed sessions, repetitions per session and reasons for protocol deviations. Secondary outcome data were obtained with voluntary MIP measurements using MicroRPM™, according to the protocol from a recently published study investigating the course of recovery of respiratory muscle strength among survivors of critical illness (14). The maximum of 3 MIP measurements was recorded twice: before the start of the training and after 6 weeks. In addition, the patient's age, gender, date of first COVID-19 infection, hospital and ICU length of stay (LOS), duration of mechanical ventilation or non-invasive oxygen therapy and medical history were retrieved from the electronic PT files.

Semi-structured interviews were conducted telephonically or at the PT clinic. Separate topic guides were developed for patient and PT interviews. Topics included: (i) previous and recent experience with IMT and the training equipment, (ii) perceived effect of the training, (iii) role of the PT and (iv) recommendations for

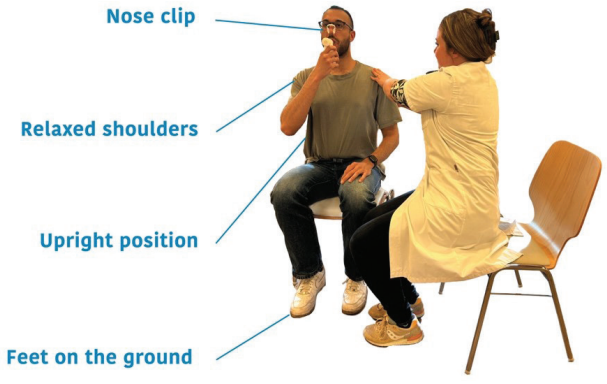

Fig. 1. Picture illustrating the correct use of the Powerbreathe©.

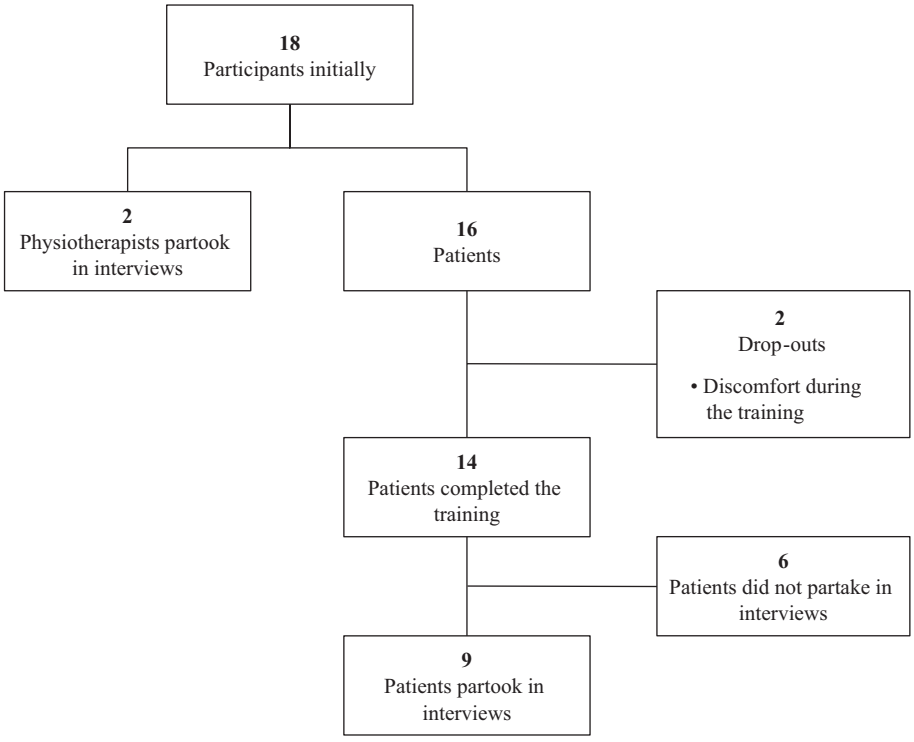

Fig. 2. Flowchart illustrating participant inclusion.

improvements (supplemental file). The research assistants who performed the interviews were unknown to the patients. Interviews were audio recorded, transcribed verbatim and anonymized.

Data analysis

We used IBM SPSS version 28 and NVIVO 2022 for quantitative and qualitative data analysis, respectively (15, 16).

Quantitative data

Patient demographic and medical data, the number of completed IMT sessions and the number and nature of protocol deviations were summarized and reported in percentages. First, MIP outcomes were reported in medians and interquartile ranges (IQR). Next, individual MIP values were converted into a percentage of predictive values, adjusted for age and gender (17).

Table I. Participants' demographic and clinical characteristics

	Patients ($n=16$)	Physiotherapists ($n=2$)
Age, median (IQR) years	51 (19.5)	
Gender, *n* (%)		
Female	12 (75.0)	1 (50.0)
Male	4 (25.0)	1 (50.0)
Participated in interviews, *n* (%)	9 (56.2)	2 (100.0)
Admitted to the hospital, *n* (%)	4 (25.0)	
Hospital LOS, median (IQR) days	5 (18.5)	
Admitted to the ICU, *n* (%)	1 (6.2)	
ICU LOS, days	14	
Mechanical ventilation ($n=1$), days	5	
Non-invasive oxygen therapy, *n* (%)	5 (31.0)	
Non-invasive oxygen therapy, median (IQR) days	4 (4.5)	

IQR: interquartile range; LOS: length of stay; ICU: intensive care unit.

Qualitative data

A phenomenological approach was chosen to capture the essence of patients' and PTs' experiences regarding barriers and facilitators related to the IMT protocol. Interview transcriptions were coded line-by-line and organized in a code list. Meaningful categories were determined from the code list and discussed in 2 reflexivity meetings to identify themes (18).

RESULTS

Population characteristics

Two PTs (1 male and 1 female) participated in an interview. Sixteen patients (female: 75% with a median (IQR) age of 51 (19.5) received the intervention and 9 patients (56.3%) were interviewed (Fig. 2). Four participants (25%) received COVID-19 treatment while being admitted to a hospital, including 1 patient (6.3%) who stayed 14 days in the ICU with mechanical ventilation for 5 days. Hospital LOS ranged from 5 to 30 days (median [IQR] 5 [18.8]). Five participants (31%) received non-invasive oxygen therapy for 2–10 days (median [IQR] 4 [4.5]) (Table I).

Adherence, protocol deviations and safety

Two participants (12.5%) discontinued the IMT in the first week due to discomfort experienced during training. No adverse events related to the IMT were observed (Table II).

Participants completed 495 out of a potential 672 sessions of IMT, corresponding to a protocol adherence of 73.7%. Reasons for non-adherence were perceived discomfort with the Powerbreathe©, fatigue, illness, being away from home or forgetting to do the training. Protocol deviations were observed in 29.7% (SD±33.4%) of the performed sessions and consisted of performing IMT more than once a day ($n=3$, 18.8%) or not being able to reach 30 repetitions in a single set ($n=7$, 43.8%). In the latter case, the PTs adjusted the protocol to 3 sets of 10 or 2 sets of 15 repetitions, dependent on the patient's capacity.

Table II. Summary of quantitative outcomes

Primary outcome: feasibility	
Drop-outs, *n* (%)	2 (12.5)
Adverse events, *n* (%)	0 (0.0)
Adherence, sessions completed (%)	495 (73.7)
Protocol deviations:	
Performed IMT more than once a day, *n* (%)	3 (18.8)
Unable to perform 30 repetitions in a single set, *n* (%)	7 (43.8)
Secondary outcome: maximal inspiratory pressure	
MIP baseline, median % of norm (IQR)	84.7% (34.0)
MIP post-intervention, median % of norm (IQR)	111.3% (66.0)

IMT: inspiratory muscle training; MIP: maximal inspiratory pressure; IQR: interquartile range.

Maximal inspiratory pressure

Baseline and follow-up data on MIP were obtained from 14 patients (87.5%). When compared to normative values, the median (IQR) MIP was 84.7% (34%) at baseline and increased to 111.3% (66%) 6 weeks later.

The following barriers and facilitators to compliance with the protocol (Fig. 3) were identified from qualitative analysis:

Barriers: getting acquainted with the training material and finding the right schedule

Participants were satisfied with the device as they described it as user-friendly, safe and easy to use. However, the nose clip was found to be uncomfortable. Participants mentioned that it took time to become acquainted with the training material and experienced that their PTs had to correct them frequently. PTs also acknowledged the importance of (initial) supervision of the IMT regime to apply corrections when necessary (Table III). Establishing a daily routine to perform the training was challenging, especially in the beginning. As a result, some participants forgot training sessions or chose to train 2–3 times a day. Ultimately, all participants managed to integrate IMT into their daily routines.

Facilitators: support from PTs and experiencing improvements

During the entire duration of the intervention, participants felt supported by their PTs. They particularly valued the verbal and written instructions they received at the start of the training and indicated that professional advice was needed to find the correct training intensity. Patients mentioned that throughout the weeks, they achieved independence in the IMT. PTs agreed with the importance of instructions on the correct device usage and regular supervision during the first weeks of the training. Both patients and PTs suggested that an instructional video might facilitate the correct utilization of the Powerbreathe©.

Experiencing improvement, observed by being able to increase the resistance on the device, was perceived as highly motivating to patients. Additionally, some participants perceived easier breathing during their PT program or independent training such as running or walking. PTs confirmed that patients developed better breathing control throughout the IMT program.

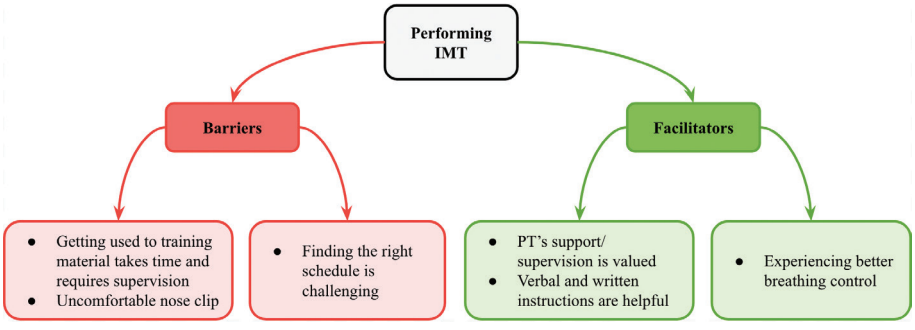

Fig. 3. Qualitative analysis – Barriers and facilitators identified

DISCUSSION

IMT seems feasible and has the potential to facilitate the rehabilitation of patients suffering from persistent dyspnoea after COVID-19. Patients and PTs perceived improvements in breathing control, suggesting a relationship between IMT and decreased symptoms of dyspnoea. These findings are consistent with a recent publication indicating that IMT might reduce dyspnoea and represent an essential home-based intervention as part of COVID-19 rehabilitative strategies (19). Yet, further research is needed to investigate potential relationships between IMT and improved outcomes for patients with persistent dyspnoea after COVID-19.

Though IMT seems feasible, PT supervision is essential, as 12.5% of the participants experienced discomfort with the intervention and needed assistance. In addition, the training protocol we used primarily targeted muscle endurance and coordination, as the number of repetitions was high and the training load was relatively low. Our findings suggest, however, that adjustment and individualization of the IMT protocol are needed, as 44% of our participants could not manage 30 repetitions at 30% of their MIP without rest intervals.

A qualitative study examining the perceptions of patients recovering from COVID-19 on IMT also found that the training needed individualization as it was challenging for patients experiencing fatigue due to their condition (20). Together with our findings, this implies that post-COVID syndrome is a complex condition involving various symptoms that must be recognized and considered when delivering IMT as a home-based

Table III. Data excerpts

Barriers	
Category	Excerpts
Getting acquainted with the training material	'It wasn't comfortable wearing this on the nose [the nose clip] even though I received 2 different clips. I didn't like it […] and stopped using it after a while'. Patient #05
	'It's useful, I think. I hope you can prove there's improvement with your machine [training material], because I think it's fairly simple. A useful system […] uh, in the beginning it was a little bit, uh, you have to get used to it'. Patient #03
	'Maybe an instructional video? Yes, so that they can watch this repeatedly. There is a video on the website of Powerbreathe, but we can add content to that I believe '. Physical therapist #01
	'It is quite tough if you do it correctly, it is not that easy. Uhm, it is tiring and finishing 30 repetitions is hard. And then there is the doubt that they might not get the desired effect. Physical therapist #01
Finding the right schedule	'Sometimes I had difficulties to, uh, to determine for myself what would be the best time to train'. Patient #13
	'…I have forgotten it (the training) once, I think'. Patient #01
Facilitators	
Support from physical therapists	'And she (physical therapist) showed real enthusiasm for this and was… she was really encouraging in this'. Patient #01
	'At the beginning, my physical therapist did it for me. He changed the levels, but then, uh, after some weeks I did it myself. Yes. And it was very easy'. Patient #07
Experiencing improvements	'[..] I became aware of my, of these muscles – I have had trouble breathing, it was like I had lost the ability to breathe properly, not quite sure [..] so yes, I had to really train this again'. Patient #01
	'I have more control over my breaths. So not only that I could breathe easier, uh, but really to feel that with every step, normally my, my breath was a bit shaky still, and I felt during, I think after 2 or 3 weeks using the Powerbreathe that I have way, much more control on how to breathe'. Patient #13
	'It did work with everyone in the end, didn't it?' Physical therapist #01

intervention. Furthermore, another recent trial found that combining IMT with manual diaphragm release was more effective than IMT alone in reducing dyspnoea (21). Therefore, an investigation of the optimal delivery mode of IMT, including dose, intensity and training components among patients with post-COVID dyspnoea, is required.

Limitations

Feasibility data were retrospectively collected through patient-reported information, potentially impacting the reliability of reported results on adherence. Additionally, important contextual information such as pre-COVID functioning, co-morbidities or previous experience with IMT is lacking. Finally, retrieving data on baseline and follow-up measurements of dyspnoea and correlating the IMT with the improvement of dyspnoea might have provided further insights into the feasibility of the training.

CONCLUSION

This pilot study shows that IMT seems feasible for patients with persistent dyspnoea after COVID, as long as it is performed under the supervision and integrated into a PT program. While evidence on optimal training parameters for IMT among this population is lacking, this short communication provides recommendations for implementing IMT in clinical practice and directions for further research.

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Conflict of interest statement

The authors have no conflicts of interest to declare.

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