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ORIGINAL PAPER

Adherence to an online exercise program for COPD patients in the home environment- a pilot study

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Abstract The objective of this study was to determine the adherence to an online exercise program for patients with moderate to very severe COPD in their home environment. The intervention consisted of three modules: module 1 online exercising; module 2 telemonitoring and module 3 telecommunication. Patients were instructed to use the service for 12 weeks after the normal rehabilitation period ended (aftercare). The study had a single-center exploratory study design. Adherence to module 1 was assessed by adherence to exercise sessions and log in time (duration in minutes) and frequency of training (amount of time a week) was measured for each patient. In addition, adherence to the exercises was measured as the percentage of performed exercises versus prescribed exercises. The adherence to module 2 was measured by logging the day and time the diary has been filled in. The adherence to module 3 was measured by logging the types of telecommunication options used. Satisfaction with the service was measured with a questionnaire, a number from 0 to 10 and whether patients would recommend the service to others. Twenty patients used the online exercise module. The adherence to the three weekly exercise protocol was 61 %. Patients logged in on average 20.3 min (±15) for 3.6 times a week (±2.3). The mean adherence to these exercises was 58 %. The adherence to the monitoring module was 82 %. Seventeen patients (77 %) used module 3 and send on average 9 messages (± 9.8) during the 12 weeks. Patient satisfaction with the service was high. The adherence to the home-based telemedicine service for patients with moderate to very severe COPD was similar to hospital-based maintenance exercise interventions. However, strategies to improve exercise adherence should be investigated.

Keywords Adherence · Exercise · Telemedicine · Compliance · Ehealth

1 Introduction

Chronic obstructive pulmonary disease (COPD) is a broad term that covers several lung conditions, including chronic bronchitis and emphysema, and is characterized by airflow limitation that is not fully reversible. The World Health Organization has estimated that COPD will become the third leading cause of death globally by 2020 [1], with patients being extensive health-care users.

Quality of life is reduced in COPD for many reasons, even in stable, well-managed patients. Despite positive improvements in quality of life following pulmonary rehabilitation (PR), it often deteriorates over time. Exercise training is known to improve physical functioning, symptoms, and quality of life for patients with COPD [2–4]. However, regular exercise training is not easily incorporated in the lifestyle of patients with COPD for whom exercise training is indicated. Although patients are encouraged to adhere to their home exercise program upon discharge, many have difficulties with the transition from institutionally-based rehabilitation into the community. Patients face multiple barriers to persue exercise including episodic exacerbations of their illness, limited ongoing support, and low self-regulatory capacity, making maintenance of independent exercise in the face of a progressive

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illness such as COPD challenging. A review of Beauchamp et al. [5] shows that most maintenance exercise programs after PR are administered in a hospital-based outpatient setting, in which patients are integrated into local community physiotherapy exercise groups. Exercise sessions are generally supervised by a physiotherapist. Poor compliance with the exercise interventions and high attrition were commonly reported. Travel and transport are frequently cited as barriers to uptake center-based programs [6]. Strategies which aim to optimize exercise adherence are required for clinical practice, as non-adherence to exercise programs is one of the key factors associated with decline in outcomes [7–9]. Home-based rehabilitation programs are preferred by patients, since they are able to spend more time with their families and can apply their training in their daily life overcoming the barrier of travel [10]. How to apply a supervised exercise training program in the home setting for prolonged effects remains a challenge. Most developed home based programs use telephone calls and visits to provide support which only allows synchronously communication between patient and professional [10]. This is time-consuming and can only occur at times the professional is available. Due to demographical changes, it seems more efficient to develop a home-based service that empowers the patient in managing his disease in his own time with minimal support of a healthcare professional.

In this pilot study, we apply a telemedicine service that supports independence and self-management of lifestyle and disorders by enabling treatment of COPD patients outside the intramural setting. This telemedicine service supports COPD patients in developing and maintaining an active lifestyle and improving their physical condition, by exercising in their home environment with a-synchronous supervision of their own healthcare professional and remote monitoring of their health status. The objective of this study was to determine the adherence to this telemedicine service for patients with moderate to very severe COPD within their home environment.

2 Methods

2.1 The telemedicine service

The telemedicine service consists of three different modules each with their own functionalities. Through a secure login, the patient and healthcare professional log into a web portal to gain access to these modules (see Fig. 1).

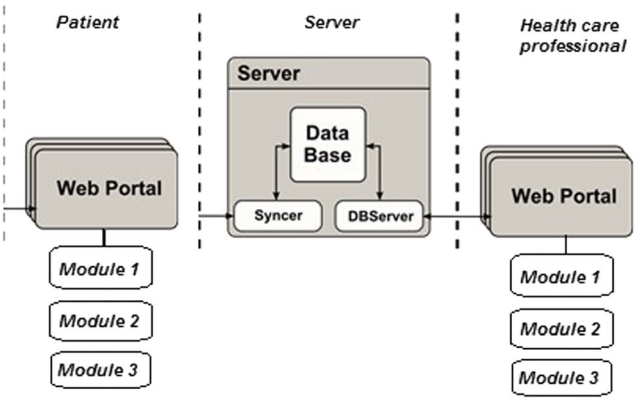


Fig. 1 High level architecture of the continuous care and coaching platform

Module 1: Online exercise program

This module has the goal to support the patient in his reconditioning at home. The module has a database of 44 video recordings of different exercises, composed and recorded by physiotherapists. Exercises are clustered into six categories as defined by the therapists, making it easier to select the right exercises. These categories are: chest mobility improvement, breathing techniques, relaxation, limber up breathing, daily activities and bronchial toilet. From the database of exercises, the health care professional selects together with the patient appropriate exercises and schedules when the patient will do these exercises during the week. For each exercise there is a video with a written and spoken description available for both the health care professionals and the patient (see Fig. 2). On the professional's portal, the health care professional gets feedback on what exercises are performed by the patient and during which moment of the day.

Module 2: Telemonitoring; monitoring of health status and disabilities

This modules makes it possible to identify health problems or to gain insight in the rehabilitation progress of the patient and can be used for optimal treatment (eg by modifying the exercise program). As such, different standardized questions are asked at fixed time intervals to gain insight into the health status of the patient. In accordance with the International Classification of Functioning Disability and Health (ICF) model, these questions focus on function (symptom parameters), activities (daily functioning and limitations) and participation (social functioning). The answers to these questions are presented in a clear overview on the portal of the health care professional. Answers are also made visible to the patient to give them insight into his health status and progress in rehabilitation.

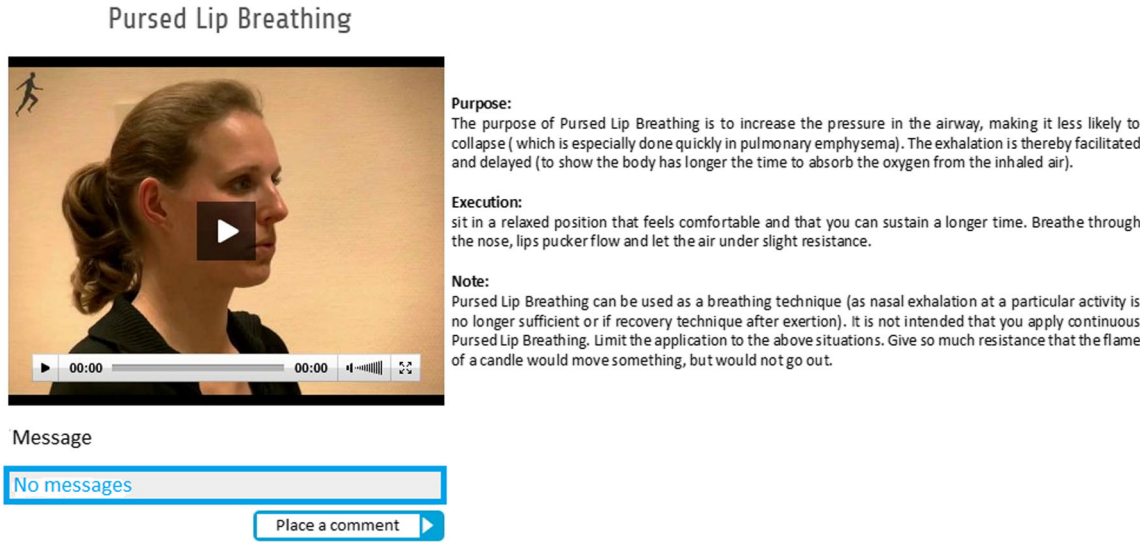


Fig. 2 Example of exercise

Module 3: Telecommunication

This module makes it possible for the patient and professional to have contact with each other. The professional and patients are notified of new messages when they log in to the portal and the new messages are shown in a clear overview. Professionals are explained that patients have the option to use telecommunication. It is up to the professional how often they view these messages and whether they respond. Patients know that there is an option to contact the professional, but the professional may not respond immediately. In case of emergency issues, they need to make contact by telephone.

There are three possibilities for telecommunication:

1) *Messages linked to exercises*

Both patients and professionals are able to put messages linked to specific exercises in the personal training program that can be used for example to indicate whether or not the exercise went well, was too difficult etc. When the patient or the professional logs onto the portal, this message is visible and a response to the message is possible (for example feedback in the form of instruction relating to the exercise, or from the patients point of view a note that the exercise caused pain).

2) *Other messages*

Direct messages between patient and professional that are not linked to specific exercises, for example about the patient's functioning or rehabilitation progress.

3) *Pin-board messages*

Patients can pin messages that are of less urgent importance on a "pin-board", for example when being on holiday.

2.2 Study design and participants

The study had a single-center exploratory study design. Inclusion criteria were: 1) moderate to very severe COPD according to the classification of the Global Initiative of Obstructive Lung Disease; 2) aged 18 years and over, 3) having a computer with internet access at home. Exclusion criteria were: 1) impaired cognitive function (such as dementia); 2) illiteracy; 3) visibility problems and 4) insufficient computer experience. A physiotherapist from the rehabilitation center identified eligible patients and invited them to participate. Prior to data collection, eligible patients were informed of the purpose and nature of the study and their written informed consent was obtained. The patients were informed on their right to refuse to participate at any time without reason and that refusing to participate in this study would have no impact on the normal care they received from the rehabilitation center.

2.3 Intervention

Physiotherapists were trained in using the new telemedicine service. All functionalities were explained and they practiced how to set an individual exercise program for patients. Patients who were willing and eligible to participate were also trained in using the system at the rehabilitation center. They also received a manual

which explained the use of the telemedicine service. Patients were instructed to use the service for 12 weeks after the normal rehabilitation period ended (aftercare). The therapists participating in this study were instructed to make an exercise program which their patients can perform at least three times a week with a duration of 12 weeks as aftercare. Professionals have the option to make an exercise program ahead for these 12 weeks at the start of the intervention, or to adjust the exercise program during the weeks of training, based on the progress and experience of the patient. Each training session should enable patients to train for at least 30 min each time. Patients were asked to fill in a diary included in the monitoring module on every training day (3 times a week).

2.4 Study outcomes

2.4.1 Adherence measures

The adherence of the three different modules have been assessed as follows:

Module 1

Adherence to module 1 of the telemedicine service (online exercising) was measured in three ways by analyzing the log data on the portal during the intervention period.

1] The adherence to the 3 day weekly exercise protocol was measured by calculating the percentage adhering to this protocol during the weeks of training for each patient.
2] The adherence to the exercises were measured which is expressed as the percentage of performed exercises versus prescribed exercises. During each training session, patients clicked a button “exercise performed” or “skip exercise” in order to continue to the next exercise in the training session. The exercises as defined “performed” are used for the adherence calculation.
3] The frequency of training (number) and duration of login (minutes) on the exercise module of the portal was measured for each patient. Frequency of training is defined as the amount of times a week patients are logged in and performed 1 or more exercises. Duration of login is defined as the total duration in minutes a patient is logged in on the portal and 1 or more exercises are performed.

Module 2

The dates (day and time) the patients filled in the diary are logged, extracted from the database and further analyzed.

Module 3

The types of telecommunication options used by the patients have been logged and are extracted from the database and further analyzed.

2.4.2 Patient satisfaction

Patient satisfaction was measured at the end of 12 weeks of intervention in the following ways:

1) Patients filled in a questionnaire that was based on the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003). The questionnaire consisted of 12 questions, which measures the patients’ satisfaction with the telemedicine service in terms of its usefulness, ease of use and their level of confidence. Each item is rated on a 1–7 Likert scale, in which a higher score indicates a higher level of satisfaction. These items are categorized in four main components being: facilitating conditions (4 items), behavioral intention (1 item), effort expectancy (5 items) and performance expectancy (2 items). The minimal score on each scale is 1, indicating low satisfaction and the maximum score is 7, indicating high satisfaction.
2) Patients were asked to rate the service as a whole with a number from 0 to 10, with 0 being not satisfied at all and 10 being completely satisfied.
3) Patients were asked whether they would recommend the service to other patients, where they could answer yes or no.

2.5 Statistical analysis

Descriptive statistics (median, mean, standard deviations, frequencies, percentages) were used to describe the sample population and to report adherence and satisfaction. SPSS version 17.0 (SPSS Inc., Chicago, IL, USA) was used.

Adherence analysis was performed for those patients who used the telemedicine service. Data for the patients that dropped out before the end the intervention are included for the period they were still using the service. Line graphs were made showing the duration of login and frequency of exercising during the 12 weeks of intervention. Column bars present the adherence to the exercises during the intervention for each week of intervention and for each patient during the whole intervention period. Adherence is calculated for different dayparts (morning: 7.00–12.00, afternoon 12.00–18.00, evening 18.00–24.00) and weekend and weekdays.

Table 1 Mean characteristics of the patients, mean (sd)

	COPD (n = 25)
Age, years	61.7 (9.3)
Sex (n)	Male 12 (48 %)
	Female 13 (52 %)
Body Mass Index (kg/m^2)	26.1 (5.7) (n = 22)
Forced Expiratory Volume in 1 s (FEV1% predicted)	42.6 (9.3) (n = 21)
Goldstatus (n)	
Stage I: mild (%FEV1 > 80 %)	–
Stage II: moderate (%FEV1 > 50 % and <80 %)	3
Stage III: severe (%FEV1 > 30 % and <50 %)	14
Stage IV: very severe (%FEV1 < 30 %)	6
	2 missing
Six minute walking test (meters)	379,8 (109.5) (n = 22)

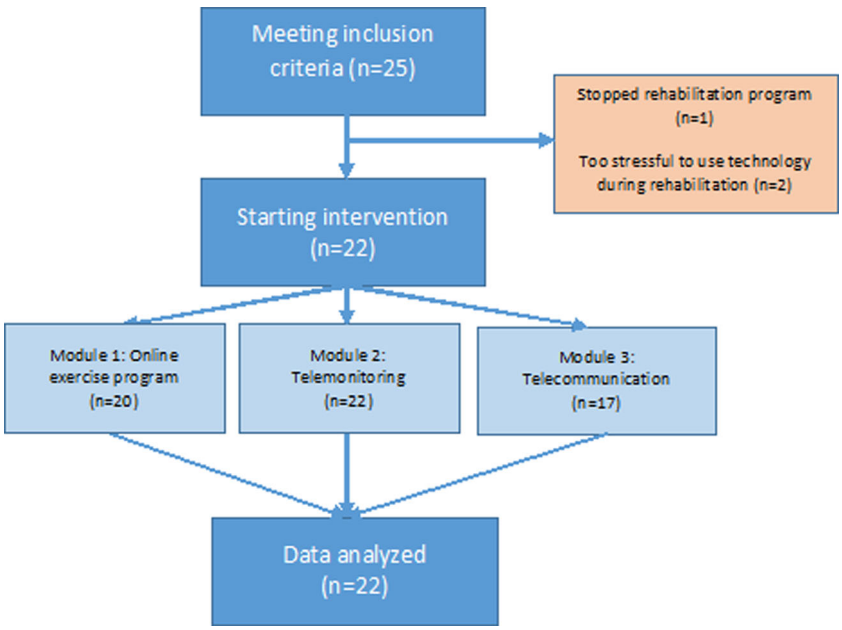
3 Results

3.1 Participants

Twenty-five patients participated in the study. Table 1 shows the characteristics of the COPD patients included in the study.

Three patients dropped-out of the study before the intervention started. Reasons for dropping out before the intervention started were: prematurely stopping rehabilitation (n = 1), and the use of the technology being too stressful (n = 2). All of the included patients who started the intervention used the online monitoring module (n = 22), 20 patients used the online exercise module and 17 patients used the telecommunication module. See Fig. 3 for a consort diagram.

Fig. 3 Consort diagram



3.2 Adherence

3.2.1 Module 1 online exercise

Twenty patients used the online exercise module. The adherence to the 3 day per week exercise protocol was 61 %. Patients trained on average 3.6 times a week (±2.3) and logged in on average for 20.3 min (±14.9) during each training session (see Fig. 4). No adverse events were reported.

On average, 22 exercises were selected for each patient for each training session. The mean adherence to these exercises was 58 % (±37). The adherence to the exercises increased during the intervention period with a mean adherence of 54 % (±35) in the first 6 weeks and 62 % (±38) in the last 6 weeks (see Fig. 5).

Figure 6 shows the mean adherence to the exercises specified for each patient, showing a high variability between patients. Five of the eight drop-outs had an adherence below 20 % (mean 21 %). Eight of the 12 patients finishing the intervention had an adherence higher than 50 % (mean 65 %).

Figure 7 shows that patients preferred to train in the morning compared to the afternoon and evening. This pattern is the same during weekdays and on weekends, with slightly more exercises performed on average during weekdays.

3.2.2 Module 2 telemonitoring

Twenty-two patients used the online monitoring module. Of those patients, 20 patients used the online telemonitoring module in combination with the exercise module. They were asked to fill in the diary at least every training day. The adherence to the monitoring module of this group was 82 %. Two patients didn't use the module at all (p14 and p21). Fourteen

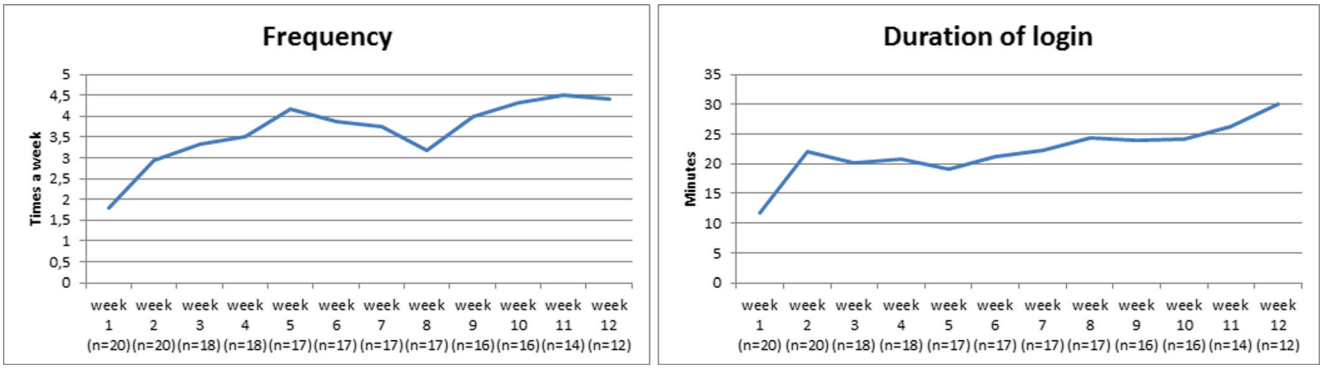


Fig. 4 Mean duration of login and frequency of training specified for each week the service is used

patients (70 %) had an adherence of 100 % and filled in the diary each day they performed exercises.

Two patients only used the monitoring module and not the exercise module. One of those patients filled in the diary 3 times a week, during the 12 weeks of intervention. The other patient used it only once.

3.2.3 Module 3 telecommunication

Seventeen patients (77 %) have used one of the three telecommunication options. Figure 8 shows the number of telecommunication used by patients to communicate with their professional.

The option of communicating with their professional using other messages (not linked to exercises) was used the most. Fifteen patients (75 %) have sent general messages to their professional, with the median number of messages send being 3 (range 1–24).

The patients that used the online exercising module (n = 20) had the opportunity to send messages linked to the exercises they had to perform. Ten of these patients (50 %) used this option and the median number of messages send to the professional that are exercise-related is 5 (range 2–32). One patient showed an extreme pattern of sending 32 messages linked to exercises and 24 other messages. Only three patients have used the pin-board option and they used it only once.

3.3 Satisfaction with the telemedicine service

Table 2 shows that patients scored on average a 6.09 (±1.33) on all three subscales, indicating high satisfaction with the telemedicine service. This is also reflected in how the patients rated the service with an 8.4 (±1.0). Nineteen patients (95 %) would recommend the service to other patients, one did not.

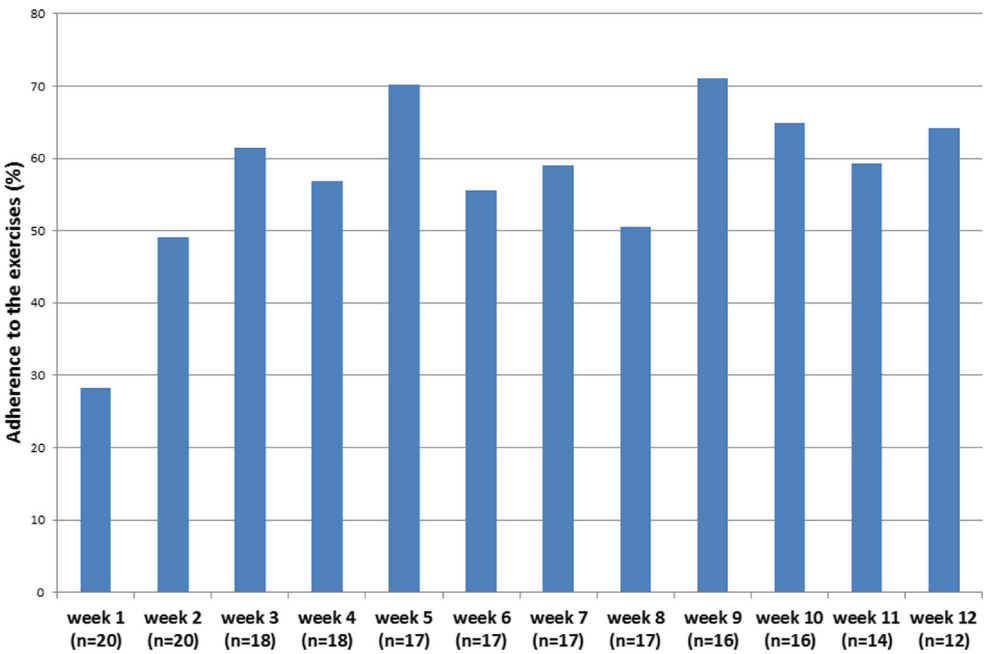


Fig. 5 Adherence to the exercises during the intervention period during the weeks

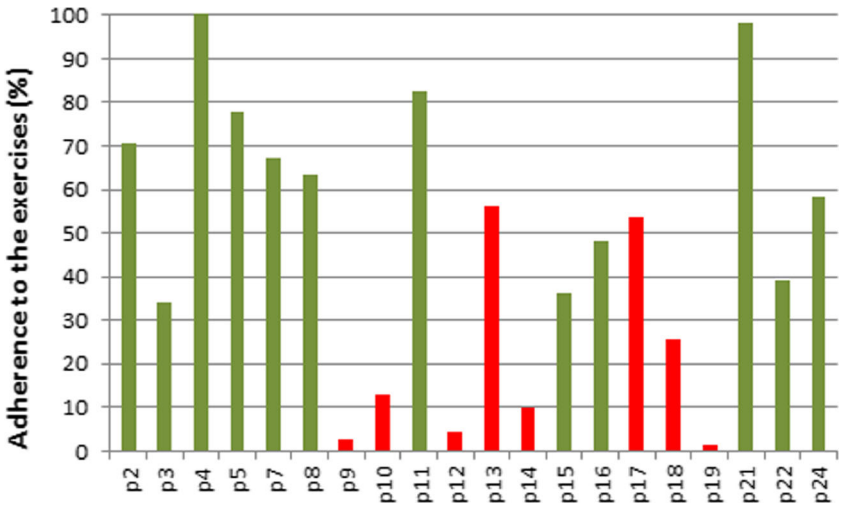


Fig. 6 Mean adherence to the exercises during the intervention period for each patient. *Green bars*, patients who completed the intervention of 12 weeks, *red bars* drop-out patients

4 Discussion

The aim of this study was to investigate how COPD patients adhere to a remotely supervised exercise training program in their home setting. The overall compliance to a 3 day per week exercise program was found to be on average 61 % and the exercise adherence was 58 %. This is in line with a review of post rehabilitation exercise programs, which report a mean compliance rate of 60 % [5]. So, the telemedicine service seems able to achieve similar adherence rates as compared to hospital-based outpatient settings. This result is positive as due the demographic changes, there is growing interest in approaches that promote exercise adherence in the home situation, with minimal burden on the healthcare system or health care professionals. However, despite high satisfaction with the service, adherence rates are not optimal. This was also seen in a study of Tabak et al. [11], who showed that the technology used was not motivating enough in the long term for doing exercises in the home environment. Motivational strategies should be incorporated to improve the service and increase the motivation of performing exercising in the future. There are different strategies possible. First, game-elements might be included to make exercising more fun and as such increase motivation [12]. This so called serious gaming is an upcoming field in health care settings and is quite new in the field of ambulant care. Incorporating game elements to the exercise module, may improve patient compliance with the service in the future [13]. Secondly, a social component might be included. Studies have shown that a lack of social support affects motivation to exercise and social motivation strategies were more effective to stimulate the participants to comply with the training plan and remain on the intervention compared to individual motivation strategies [14]. As such, adding social support and interactive features might increase usage of online home exercise programs in the long-term. For example by continuing the group support of the intramural rehabilitation setting in the online exercise module. To facilitate such group support, features could be included in the program to make contact with others easier, which is important for completion of an exercise program [15,

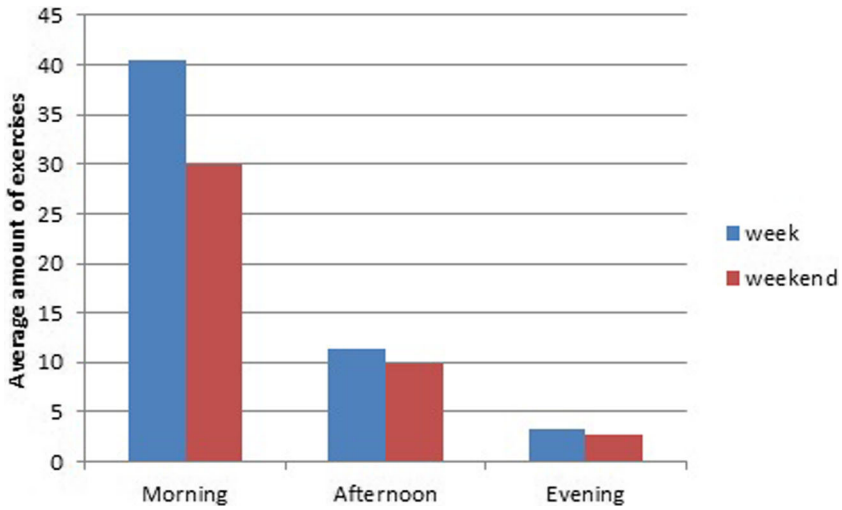


Fig. 7 Average amount of exercises performed on three dayparts during weekdays and on weekends. Morning: 7.00–12.00, afternoon 12.00–18.00, evening 18.00–24.00 o'clock

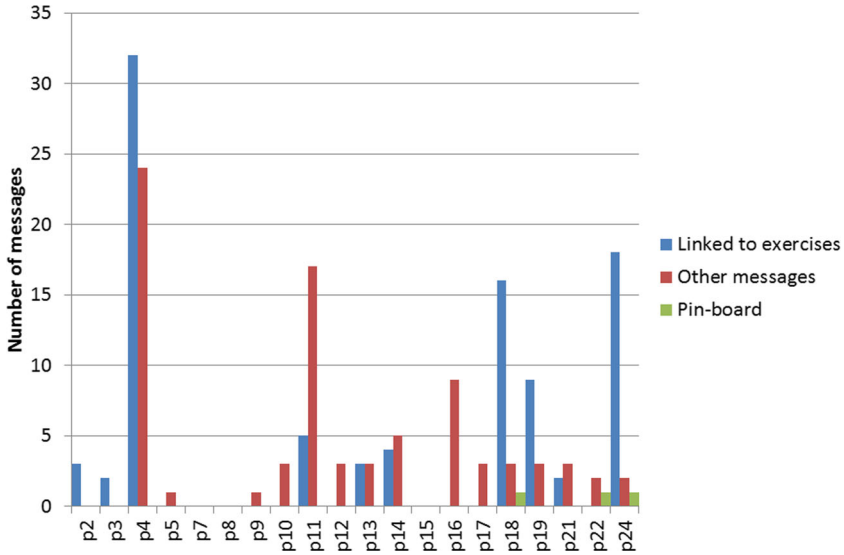


Fig. 8 Total amount of messages send by the patients for the three communication options during the intervention period

16]. Examples of this are: chat, profile with a status field or a wall where one can post messages, pictures, videos, and leave comments to each other. Further development and incorporation of social, and fun to use components in exercise interventions is therefore an important way to increase exercise adherence, which might result in more long-term effects. Future research should focus on the effectiveness of these specific motivation strategies in order to increase exercise adherence.

Patients preferred to train in the mornings with no influence of week or weekends. This might be explained by the fact that COPD patients often experience daily symptom variability, with the morning being the worst time of the day [17]. Shortness of breath is considered by COPD patients to be the most troublesome morning symptom and most likely to affect quality of life [18]. As such, this might have increased motivation to do the exercises in the morning compared to the afternoon and evening. Although patients seemed motivated to train in the morning, the drop-out rate in this study was high; (45 %) and increased during the weeks. To decrease this drop-out rate in the future is a challenge. The drop-out rate reported in PR programs is among 20–40 % [19–21]. When the dropout rate is so high even in time-limited, specially adapted PR programs, it is reasonable to assume that the challenges related to dropout are even greater when the patients themselves are responsible for maintaining an exercise program. A review of Beauchamp et al. [5] showed that 24–61 % of patients dropped out during the exercise maintenance interventions, 1 year after primary PR. There are many reasons why people with COPD find it difficult to continue exercising. Professional support through positive and empowering physiotherapists and adaption of intensity of the exercise program are two of the key factors in sustaining regular physical activity [22]. Another factor that is recognized as being important for completion of a PR program is clinical benefit [23, 24]. COPD patients are often not aware that exercise helps to improve their health [16]. These factors are important to take into account when further developing and implementing the service into clinical practice. Patients should be well informed about the benefits of attending the program by their own physiotherapist. Professionals are important in helping patients understand the nature of the disease and potential benefits of treatment and encouraging the development of self-management skills [25]. As such, their attitude toward telehealth treatment can greatly influence the adherence of patients. They need to clearly explain why pulmonary

Table 2 Satisfaction with the telemedicine service (mean; standard deviation (sd)) (range 1–7)

Items	Mean	SD
Facilitating conditions	6.08	1.46
I had the capabilities to use the telemedicine service	6.15	1.04
I had the facilities to use the telemedicine service	5.85	1.66
I had enough space to exercise at home	6.45	1.28
I had sufficient peace at home to use the service	5.85	1.79
Behavioral intention	5.95	1.64
When possible, I have the intention to use the service in the future	5.95	1.64
Effort expectancy	6.25	0.96
The online exercise module was clear	6.35	0.93
The online exercise module was easy to use	6.35	1.14
The online monitoring module was clear	5.95	1.05
The online monitoring module was easy to use	6.05	0.95
The instructions of the exercises were clear to me	6.55	0.61
Performance expectancy	6.10	1.28
Online exercising was a valuable addition to my treatment	6.40	1.10
Online monitoring was a valuable addition to my treatment	5.80	1.40

rehabilitation is important and highlight the potential benefits to empower and motivate patients to exercise at home.

4.1 Limitations

The most significant limitation is the small number of individuals taking place in the study. Also the lack of a follow-up hampers any conclusions about the program being able to motivate patients to continue exercising in their home environment after the use of the program. However, being a pilot study, important information regarding the adherence and satisfaction of the online exercise program were found.

There were two limitations in the adherence calculations: 1) The adherence calculation was dependent on the patients' honesty. We have to trust the fact that when they defined the exercise as being performed, they have actually performed the exercise. A better adherence estimate can be made when using for example sensor techniques where patients have to carry movement sensors while exercising. 2) The adherence rates are based on the data available to the patients that are still using the online exercise module. Results show that the less adherent group drops out, thus increasing the overall adherence estimate.

Finally, the overall compliance to the telemedicine service and the adherence rates are likely to be overestimated. Reasons for this overestimation might be a selection bias of patients. Patients who entered the intervention might have been more motivated to exercise, resulting in higher adherence rates.

4.2 Conclusion

The adherence to the home-based telemedicine service for patients with moderate to very severe COPD was similar to hospital-based maintenance exercise interventions. However, motivational strategies to improve exercise adherence should be investigated.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

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