Evaluation of a 12-Week Smartphone-Based Physical Activity Telecoaching Intervention in Chronic Obstructive Pulmonary Disease: Patient Experiences and Lessons for Implementation

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Submitted to: JMIR mHealth and uHealth
on: January 25, 2018

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Abstract

Background: Telecoaching approaches can enhance physical activity (PA) in patients with chronic obstructive pulmonary disease (COPD). However, their effectiveness is likely to be influenced by intervention-specific characteristics.

Objective: This study aimed to assess the acceptability, actual usage, and feasibility of a complex PA telecoaching intervention from both patient and coach perspectives and link these to the effectiveness of the intervention.

Methods: We conducted a mixed-methods study based on the completers of the intervention group (N=159) included in an (effective) 12-week PA telecoaching intervention. This semiautomated telecoaching intervention consisted of a step counter and a smartphone app. Data from a project-tailored questionnaire (quantitative data) were combined with data from patient interviews and a coach focus group (qualitative data) to investigate patient and coach acceptability, actual usage, and feasibility of the intervention. The degree of actual usage of the smartphone and step counter was also derived from app data. Both actual usage and perception of feasibility were linked to objectively measured change in PA.

Results: The intervention was well accepted and perceived as feasible by all coaches present in the focus group as well by patients, with 89.3% (142/159) of patients indicating that they enjoyed taking part. Only a minority of patients (8.2%; 13/159) reported that they found it difficult to use the smartphone. Actual usage of the step counter was excellent, with patients wearing it for a median (25th-75th percentiles) of 6.3 (5.9-6.8) days per week, which did not change over time (P=.98). The smartphone interface was used less frequently and actual usage of all daily tasks decreased significantly over time (P<.001). Patients needing more contact time had a smaller increase in PA, with mean (SD) of +193 (SD 2375) steps per day, +907 (SD 2306) steps per day, and +1489 (SD 2310) steps per day in high, medium, and low contact time groups, respectively; P for-trend=.01. The overall actual usage of the different components of the intervention was not associated with change in step count in the total group (P=.63).

Conclusions: The 12-week semiautomated PA telecoaching intervention was well accepted and feasible for patients with COPD and their coaches. The actual usage of the step counter was excellent, whereas actual usage of the smartphone tasks was lower and decreased over time. Patients who required more contact experienced less PA benefits. Clinical Trial: Clinicaltrials.gov NCT02158065; http://clinicaltrials.gov/ct2/show/NCT02158065 (Archived by WebCite at http://www.webcitation.org/73bsaudy9)

(JMIR Preprints 25/01/2018:9774)
DOI: https://doi.org/10.2196/preprints.9774

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Paper type: original paper

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Conclusions: The 12-week semi-automated PA telecoaching intervention was well accepted and feasible for patients with COPD and their coaches. Actual usage of the step counter was excellent, while actual usage of the smartphone tasks was lower and decreased over time. Patients who required more contact experienced less PA benefits.

Trial registration: NCT02158065 (clinicaltrials.gov)

Keywords: Physical activity; telecoaching; actual usage; feasibility; acceptability; COPD

Introduction

Reduction in physical activity (PA) is a major feature of Chronic Obstructive Pulmonary Disease (COPD), occurring both as a consequence of disease and driving worse outcomes in the condition [1]. PA coaching has been recommended as a non-pharmacological treatment strategy for patients with COPD, across all stages of the disease [2]. Telecoaching, where support is provided to achieve effective behavior change by use of electronic communication strategies, has received increasing attention in recent years [3]. It offers the possibility of coaching patients from a distance in an automated or semi-automated way, thereby reducing the burden of face-to-face interactions for patients and health care providers. The latter type of intervention is an example of a complex intervention, which consists of several interacting components [4]. This interaction between multiple components complicates the implementation of such interventions [4]. Therefore, process evaluations have been proposed by the UK Medical Research Council [5], which offer the possibility to investigate how the intervention was delivered (i.e. why the intervention worked/did not work) in addition to whether it was effective or not. This is of crucial importance to health technology assessment bodies as it provides information on which components of an intervention were effective/ non-effective and on how the intervention can be improved and replicated in different settings and patient groups [4,5]. Process evaluation can also be of great value in evaluating PA telecoaching interventions, which have been shown to be effective in enhancing PA in some studies [6–8], but not in others [9]. In a recent multicenter PA telecoaching trial (MrPAPP study), which had a positive outcome [6] a large variability in the effect of the intervention was noticed. Patients with better functional exercise capacity (i.e. six minute walking distance (6MWD) ≥ 450 meters), fewer symptoms (i.e. modified Medical Research Council (mMRC) dyspnea scale ≤2) and those in GOLD A-B improved their PA to a greater extent [6]. In addition to these patient characteristics, intervention specific characteristics and the way patients cope with the intervention may also have contributed to the success of the intervention. In the present paper, three concepts, which are often assessed as part of a process evaluation, have been investigated: A) acceptability, B) actual usage and C) feasibility of the intervention from both a patient and a coach perspective. In addition, we aimed to investigate their association (i.e. actual usage and feasibility) with the effectiveness of the intervention. First, acceptability is a key concept in the development, evaluation and the implementation of complex interventions and can have significant impact on the intervention's effectiveness [10]. It has been defined as "a multi-faceted construct that reflects the extent to which people delivering or receiving a healthcare intervention consider it to be appropriate, based on anticipated or experienced cognitive and emotional responses to the intervention" [10]. A potentially effective intervention might not reach its potential due to poor acceptability to patients or healthcare providers [10].

Second, the actual usage of the intervention by patients and healthcare providers forms an important part of the delivery of PA telecoaching interventions. Actual usage was assessed as the degree to which patients used the components of the interventions as it was designed [11]. It is often confused with the term 'adherence' [12]. The latter term requires a rationale for the minimum intended use of the components of the intervention. As there is no established minimum usage of such PA telecoaching interventions, we used the term 'actual usage', with the assumption of the more usage the better [12]. While the actual usage of step counters is known to be relatively good in short-term coaching trials involving patients with COPD [7,13,14], actual usage of smartphone applications in coaching trials has been less intensively studied.

Third, the implementation of this intervention also depends on whether it was considered to be feasible by patients as well by the coaches. Feasibility is defined as "the extent to which a new treatment, or an innovation, can be successfully used or carried out within a given agency or setting" [15,16]. The coach feasibility of the PA telecoaching program in this paper has already been partly assessed in the main paper of the MrPAPP trial, which reported that coaches contacted patients for a total duration of 50 minutes throughout the trial [6]. However, qualitative data on the perceived feasibility of both patient and coach is lacking.

Finally, the direct association between both coach feasibility (as assessed by contact time) and actual usage by patients with the effectiveness of the intervention was investigated. The latter insights could lead to improved design and implementation of PA telecoaching interventions in the future as well as optimized selection of patients.

Methods

Study Population & Design

A convergent mixed methods design using quantitative and qualitative data was applied to evaluate the acceptability, actual usage and feasibility of a PA telecoaching intervention. Both qualitative and quantitative data on the intervention were separately collected and analyzed. Afterwards, these findings were compared for data triangulation, which allowed a more comprehensive understanding of the intervention [17–19].

The present trial forms part of a 12-week, multicenter randomized controlled trial (1:1 randomization) conducted by the PROactive consortium [6]. The trial consisted of 3 visits – a screening visit (V1), a randomization visit (V2) 1 to 2 weeks later, and a final visit (V3) 12 weeks post randomization. In total, 171 patients were allocated to the intervention group in 6 centers across Europe [Leuven (Belgium), Athens (Greece), London and Edinburgh (United Kingdom), Zurich (Switzerland) and Groningen (The Netherlands)] between June and December 2014 from which 159 patients completed the trial and were considered for the present analyses. More information on the study population and design has already been published elsewhere [6]. All patients provided informed consent prior to any data collection. This study was approved by the local ethics committee at each centre.

Physical Activity Telecoaching Intervention

Patients in the intervention group [6], received a multicomponent PA telecoaching intervention, consisting of a step counter and a smartphone application (Samsung Galaxy S4 mini; android version 4.4.2), in addition to usual care. Furthermore, patients in the intervention group received an exercise instruction booklet for home use and a one-to-one interview with a coach discussing motivation, barriers, favorite activities and strategies to become more active. The exercise instruction booklet contained three different sessions of upper limb and lower limb stretching, balance and strengthening exercises with a standardized amount of sets and repetitions (see Multimedia Appendix 1). Patients were asked to wear the step counter (Fitbug air©) during waking hours and to interact with the project-tailored smartphone application on a daily basis. They were instructed to access and review automated tasks that appeared on the smartphone's display and to press the "close" box on the screen afterwards (i.e. completion of a task). An audio reminder was provided for patients to send their step data at 8 PM to their smartphone (through Bluetooth) by pressing a single button of the step counter. The application provided patients with daily activity goals in the morning, which were set for one week. The patient's goal was adjusted according to their PA performance in the previous week and to their willingness to increase their goal. Goals were calculated based on the median of the 4 most active days of the previous week. If the latter value was higher than the weekly goal (i.e. patients reaching the goal), the patients had the opportunity to A) not change or B) increase their goal by 500 steps via a 'yes' or 'no' option displayed on the application. If the median of the 4 most active days of the previous week was more than 500 steps below the goal (i.e. patients not reaching their goal), the goal was reduced to the median of the 4 most active days + 500 steps. In other cases, the goal remained the same. Coaches were asked to contact the patients (i.e. tasks of the coaches) in case patients 1) did not send their step count data for 3 consecutive days 2) did not reach their target for 2 consecutive weeks; 3) reached the target but they were not willing to increase for 2 consecutive weeks; 4) were not adherent with wearing the step counter for 2 consecutive weeks. More details on when coaches were instructed to contact the patients (i.e. flagging system) are published elsewhere [6]. Daily and weekly encouraging feedback messages were displayed on the smartphone using both text and pictograms (see Multimedia Appendix 2; slide 7). Throughout the whole intervention period, coaches could access patient data via their application-linked web accounts to monitor patient's performed PA and their actual usage of the intervention (PROactive Linkcare application, Barcelona, Spain; see Multimedia Appendix 2). The use of the intervention was completely free of charge for all patients. No major bug fixes or changes to the intervention were made throughout the trial. A detailed overview of how the intervention works can be found in

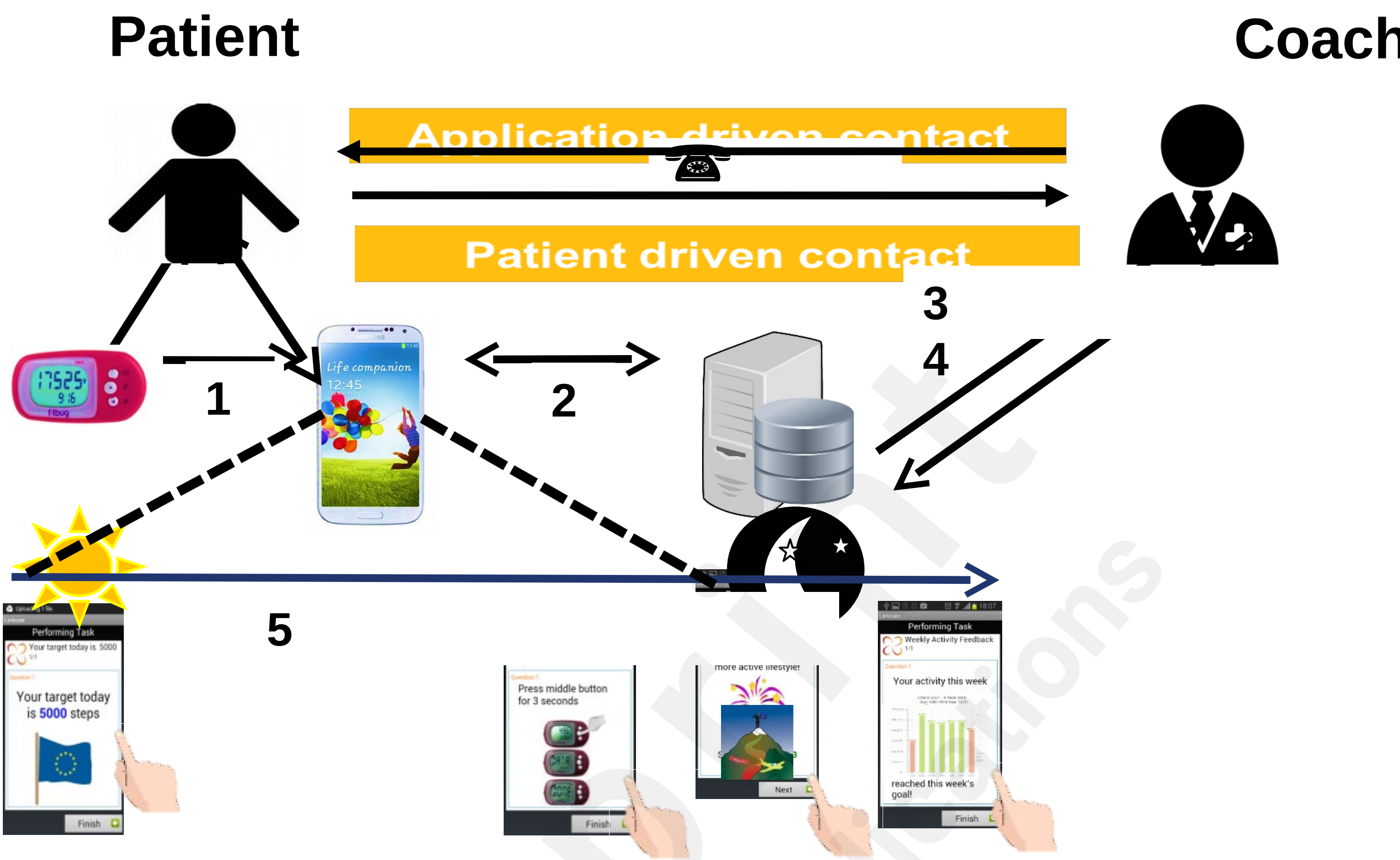


Figure 1. Overview of the intervention; 1= sending of “steps data” to smartphone (through Bluetooth); 2= data sent to central database; 3= coach is able to access database; 4= coach is able to manually adjust goals, 5= accessing & closing the different tasks on the smartphone application (automated messages); i.e. (from left to right); morning goal, send activity in the evening, daily feedback (from Monday to Saturday), weekly feedback (only on Sunday) tasks.

Outcomes

Acceptability

Acceptability was assessed via quantitative data [a project-tailored questionnaire (20 items, Multimedia Appendix 3)] and qualitative data collection [patient interview (4 open questions, Multimedia Appendix 4) and a coach focus group (Multimedia Appendix 5)].

During the final visit of the study (V3), patients were asked to fill in a 20-minute self-administered, project-tailored, multiple-choice questionnaire on their experiences with the intervention and the usefulness of its components on a 10-point Likert scale (Multimedia Appendix 3). Each center collected and anonymized answers from all their patients into an excel file which was sent to one investigator (HD). HD pooled all data together into one excel file, which was then used for analysis.

Patient interviews were conducted by local PA coaches in each center at V3. Each coach was informed and trained on how to conduct the interview during an investigator's meeting prior to the start of the trial. Interviewers from each center were asked to transcribe the answers of the patients to the discussion guide questions and forward them (anonymized) to one researcher (ML) who collected all quotes into 1 excel file for analysis. In this pooled excel file, each line represented the verbatim answer of each participant on a question with a number code and a letter representing respectively the patient's ID and the question of the discussion guide.

After completion of the trial, an audio-taped focus group was organized to capture the intervention experience from the perspective of the coaches. Local PA coaches with a diverse background [i.e. medical doctor (RR), physiotherapist (ML, HD), exercise physiologist (ZL), biomedical scientist (MS), psychologist (AF); n=6] and two experienced physiotherapists who were involved in the development of the intervention (n=2; EG, AA from the center in Barcelona (IS GLOBAL)) discussed the feasibility, appreciation, possible future adaptations, time investment and actual usage of the different components of the intervention (Multimedia Appendix 5). Two PA coaches (ML, HD) facilitated the focus group.

Actual usage

Actual usage of the intervention by patients was assessed objectively through the smartphone application log. A database was derived directly from the smartphone application. This included information about completion of the application tasks and step counter data on a day-by-day basis. Actual usage of the step counter was defined based on the presence of step count data (i.e. ≥70 steps for that day).

Self-reported actual usage of performing home exercise and the times patients looked at their step counter were assessed subjectively in the project-tailored questionnaire.

Actual usage by the coaches was assessed based on the closure of tasks in the application-linked web accounts and discussed during the coach focus group.

Feasibility

Coach feasibility was already partly assessed in the main paper of the MrPAPP trial in terms of number of contacts and total amount of contact time between coaches and patients (quantitative data) [6]. As a secondary analysis, the evolution in efficiency of coaches, as measured by contact time throughout the study recruitment period, was assessed. In addition, coach perception of the feasibility of the intervention was also covered in the coach focus group (qualitative data). Intervention feasibility from the patient perspective was evaluated via the project-tailored questionnaire (quantitative data) and patient interviews (qualitative data).

Association of Actual usage & Feasibility with the Effectiveness of the Intervention

Both actual usage by patients and coach feasibility (i.e. contact time) with the intervention were separately linked to the effectiveness of the intervention. This effectiveness was assessed as the change in numbers of steps/day after 12 weeks, measured by the Actigraph GT3x (ACT, Actigraph LLC Pensacola, FL). The latter is a tri-axial accelerometer validated for use in patients with COPD [20,21]. Further details on the PA assessment methodology can be found elsewhere [6].

Statistical Analysis

All statistical analyses were performed with statistical software package SAS version 9.4 (SAS Institute, Cary, NC). Continuous variables were expressed as means with standard deviation (SD) (normal distribution) or as medians [25th and 75th percentiles (P25-P75)] (skewed distribution), unless stated otherwise. Categorical variables were expressed as proportions and percentages. The level of significance was set at 0.05 for all statistical tests. The analyses were based on patients in the intervention group who completed the 12-week intervention (n=159).

Data from the project-tailored questionnaire were scored as categorical variables and reported as frequencies and percentages (i.e. number of patients indicating each answer), except for the usefulness ratings of the components, which were expressed as median [(P25-P75)].

For analysis of the interview data, two researchers (HD, FR) independently performed thematic analysis on the excel file containing the verbatim transcriptions of the interview data [22] according to the 6- step framework as proposed by Braun and Clarke's [23]:

1) HD and FR read the data multiple times and descriptively noted down their initial ideas of what is in the data and what is interesting about them.

2) HD and FR independently generated an initial list of codes from the data and put the data systematically under certain headings.

3) Afterwards, they searched for reoccurring themes, which began to emerge from these codes to focus their analysis on a broader level.

4) HD and FR refined and defined their themes taken into account the overall message of the analysis. Themes and subthemes were organized and ranked into categories.

5) HD and FR came together for group discussion to find an agreement on defining the themes and subthemes, which led to the development of a (final) codebook.

6) Afterwards, one researcher (ML) applied the final codebook to all verbatim transcripts. After iterative group discussions, data was synthesized and representative example quotes were extracted to illustrate findings and were labelled by a unique participant's code together with the category of contact time and actual usage score of that participant.

The thematic analysis was conducted inductively (i.e. themes emerged from the data, hence without pre-determined coding frame) in excel, without the use of specialized analytic software. Further details on the methodological aspects of the latter analyses have been added to the COREQ checklist (cfr. Multimedia Appendix 6).

During the focus group, one PA coach (ML) wrote a consensus summary. Two PA coaches (HD, MS) independently reviewed the consensus summary based on the audio recording. Additional information that was considered as relevant was independently added by both coaches (HD, MS). Only minor interpretation disagreements occurred between the two PA coaches, which were discussed together with a third PA coach (ML). Afterwards, a summary of the focus group was sent for revision to all PA coaches, including those who could not be present at the focus group. A consensus quote on the future implementation of the present PA telecoaching intervention was formulated.

Actual usage was compared according to age (<65 vs ≥65 years, Mann Whitney U test), gender (Chi square test) and over time in the trial (week 2-3 vs week 11-12, Wilcoxon signed rank sum test). Actual usage of the step counter was expressed as the percentage of patients who wore the step counter for at least 90% of the days in the study. Actual usage of the different smartphone tasks was expressed as median [(P25-P75)]. In the larger centers (inclusion of at least 20 patients), the contact time with the first 10 patients was compared to the others (Mann Whitney U test) to assess possible learning effect of the coaches.

We attempted to create 3 equally balanced groups (low, medium, high) of total contact time (Figure 2) and of an overall score of actual usage. This overall actual usage score was calculated by summing up each actual usage component (actual usage of all tasks and wearing the step counter) as a percentage of their recommended frequency. The three groups were compared (ANOVA test or Kruskal-Wallis) to characterize those who required a lot of contact time and those who did not and those who had high actual usage of the intervention and those who did not. As a sensitivity analyses for the latter tertiles approach, we also analyzed contact time and actual usage score as continuous variables. The methodology used for the latter sensitivity analysis can be found in Multimedia Appendix 7.

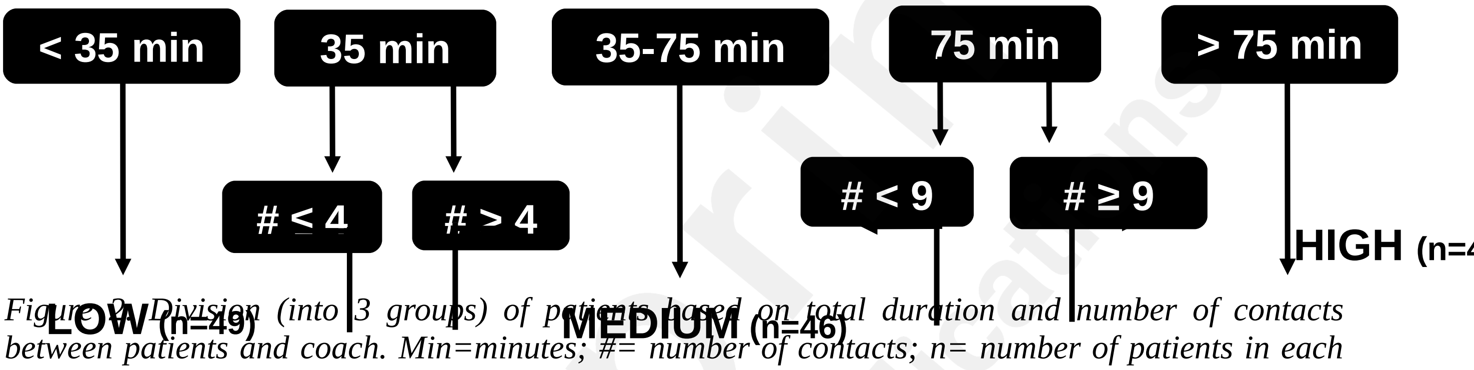


Figure 2. Division (into 3 groups) of patients based on total duration and number of contacts between patients and coach. Min=minutes; #= number of contacts; n= number of patients in each group.

To analyze the association between 1) the actual usage by patients of the different components of the intervention and coach feasibility (i.e. contact time) with 2) the effectiveness of the intervention, two separate generalized linear model analysis (proc GLM) were used in completers with valid PA data (88.1% or 140/159 of the completers sample). Change in PA was used as the outcome and respectively contact time and actual usage as the class variables. Because of their possible influence on the intervention effect, baseline exercise capacity (6MWD), symptom score (mMRC-scale), Forced Expiratory Volume in 1 second (FEV_1) %predicted and the number of acute exacerbations in the previous 12 months were considered as possible (continuous) covariates of the association [6]. Details on sensitivity analyses for the latter tertiles approach (with contact time and actual usage scores as continuous variables) can be found in Multimedia Appendix 7. Finally, we hypothesized high contact time in the first 4 weeks to be an early sign of absence of response to the intervention. To that end, we calculated the likelihood of achieving the MID improvement of 1000 steps/day [24] in patients with a low (≤30 minutes) and high (>30 minutes) contact time in the first 4 weeks (as a possible early predictor for treatment failure).

Results

Study Population

Baseline characteristics of the 159 completers are outlined in Table 1. Baseline characteristics of the completers of the trial. Information on the full study population (including further details about drop-outs and the occurrence of adverse events) have been detailed elsewhere [6].

Table 1. Baseline characteristics of the completers of the trial.

Variables	**Intervention completers (n[a]=159)**
Age (years), mean (SD[b])	66 (8)
Female/male, n (%)	51 (36) / 89 (64)
BMI[c] (kg/m^2), mean (SD)	26.9 (5.3)
FEV_1[d] predicted (%), mean (SD)	53.9 (19.9)
6MWD[e] (m) , mean (SD)	442 (107)
6MWD predicted (%), mean (SD)	70.3 (16.5)
CAT score[f], mean (SD)	13 (8)
QF[g] (kg) , mean (SD)	31.5 (10.9)
PA[h] (steps/day) , median [P25-P75][i]	4272 [2783 to 5768]

[a]number of patients
[b]Standard Deviation
[c]Body Mass Index (BMI) in kilogram/meters^2
[d]Forced Expiratory Volume in one second (FEV_1) in % predicted
[e]Six Minute Walk Distance (6MWD) in meters; 6MWD was missing in 2 patients
[f]COPD assessment test (CAT)
[g]Quadriceps Force (QF) in kilograms. QF was not measured in 2 centers and QF was missing in 27 patients
[h]PA, Physical Activity (PA) in steps/day, valid PA measurements was present in 140 patients.
[i]25th and 75th percentiles [P25-P75]

Outcomes

Acceptability

Overall, the PA telecoaching intervention was well received by the patients as 89.3% of them

(142/159) indicated that they "enjoyed taking part in the intervention". Furthermore, the majority of the patients (59.1%, 94/159) claimed that the intervention coached them "a lot" towards enhancing their PA. Approximately half of the patients (47.2%, 75/159) experienced the proposed weekly increases in step counts as "reasonable", while respectively 37.7% (60/159) and 10.1% (16/159) of the patients experienced these increases as "a little bit too high" and "much too high".

Patients rated the usefulness of the step counter (10 [8-10]) and the telephone contacts with the coach in case of problems (9 [7 to 10]) as the most crucial parts of the intervention (see Figure 3). The display of a daily (educational) activity tip in the evening (6.5 [5 to 8]) and the booklet for home exercises (6 [4 to 8]) were rated as less useful.

Figure 3. Boxplots depicting the usefulness score (0-10 Likert scale) of the different parts of the intervention from the patients' perspective. "APP" between brackets represents messages displayed on the smartphone application.

When patients were asked to name the most important part of the intervention, 76.1% (121/159) of patients did choose the step counter as most the important part with 93.1% (148/159) of all patients willing to continue using the step counter in the future. In total, 45.9% (73/159) of all patients were willing to continue using the full application with only 8.2% (13/159) of all patients reported to experience working with the smartphone as difficult.

In total, 145 patients (91.2% or 145/159 of the completers sample) took part in the semi-structured interviews at V3. Themes and subthemes that were derived from the verbatim responses of patients to the interview are presented in Table 2. Findings of the thematic analysis of the interview data are categorized under 1) technical aspects and 2) aspects related to the content of the intervention. Two major topics can be distinguished from the interview data: technical aspects and aspects related to the content of the intervention *(cfr. Table 2). Illustrative quotes, which support findings from the thematic analysis are provided in Multimedia Appendix 8. Further information on the interview process, participants and the interviewers can be found in the COREQ-checklist (cfr. Multimedia Appendix 6).*

Table 2. Findings of the thematic analysis of the interview data are categorized under 1) technical aspects and 2) aspects related to the content of the intervention.

TECHNICAL ASPECTS Themes of 1) positive experiences and 2) issues/problems emerged from the data. Subthemes are labelled by alphabetic letters.	
1) Positive experiences	
a) No technical problems	A large portion of patients stated not to have encountered technical issues with any of the components of the intervention.
b) Working with application	The ease of use with the different components of the intervention was highlighted by patients. Furthermore, patients who had less a priori experience with managing a smartphone device expressed that the learning process of working with this device was smooth.
2) Issues/problem	
a) Help from others	Few patients needed more than a familiarization period before they were able to feel confident about working with the smartphone and its application. Help from both the

		study team (via phone calls or face-to-face contacts) and from their relatives was considered essential when experiencing problems.
b)	Speed of interaction with the application	Some patients felt the speed of the application was slow and perceived the interaction with it as time consuming. Especially the transfer of step data onto the phone in the evening was delayed for several minutes.
c)	Application problems	Some patients reported during the interview that working with the application was often hindered (e.g. tasks not opening, not possible to send data). Reasons for these application problems were mostly related to issues with the internet connection or Bluetooth problems.
d)	Step counter	A small minority of patients expressed their frustration with the step counter that was not always able to detect all steps they performed. Activities such as slow walking, cycling and arm movements were not measured accurately.
ASPECTS RELATED TO THE CONTENT OF THE APPLICATION Themes of 1) positive experiences 2) issues/problems and 3) outcome emerged from the data. Subthemes are labelled by alphabetic letters.		
1)	*Positive experiences*	
a)	Step counter	The step counter was judged as the essential part of the intervention by several patients due to its simplicity, feedback and its usefulness.
b)	Graphs	Another highly rated aspect of the intervention were the graphical feedback displays that patients received based on the achievement of their goals. According to the patients, it was an interesting and excellent way of motivating them.
c)	Nice experience	In general, the intervention was considered as motivating to a large majority of patients across the different centers. Patients claimed it was a fun and interesting experience that helped them towards being more active and feeling better and fitter.
d)	Being monitored	One of the most important motivational reasons according to patients to become more active was the feeling of being monitored. Knowing that the coaches were following them up gave them an external motivational cue to be physically active.
e)	Family participation	Next to the help from the coaches, patients' relatives often played an important supportive and stimulating role throughout the intervention. Close relatives of patients (mostly spouses) also bought a step counter to join their wife/husband throughout their coaching.
2)	*Issues/problems*	
a)	Goals	One of the most important issues was the increase in the step count goal, which was often too high for patients. This caused some frustration among patients as it was perceived

	as demotivating to have too high goals and not being able to reach them.
b) Variation	As the intervention was used for a period of 12 weeks, the component of variation in the content of the application was deemed as important according to the patients. Some patients reported that due to the lack of variation, their actual usage of the intervention (in particular with the opening of the messages on the smartphone) lowered. The morning messages with the goal patients needed to achieve were repeated every day of that week and required more variation according to the patients.
c) Barriers	One of the major drawbacks of the intervention according to patients was that it did not take into account several barriers with which they were confronted. When a patient experienced an acute exacerbation, his/her goal was not adjusted immediately. Weather factors were not taken into account within the application. Furthermore, patients regretted that there was no option for them to make the intervention aware that they had other priorities (e.g. holidays or days when they needed to watch their grandchildren).
d) Motivational issues	A few patients did not find the application interesting and did not like working with it.
3) Outcome	
a) New routine	Patients stated that the intervention and the goals resulted in the adoption of new lifestyle routines to be more physically active. They hoped to continue with these more active lifestyles after the intervention finished.

All coaches present at the focus group, considered the intervention to be a useful addition to standard care in patients with COPD. The coaches rated the step counter as very useful, mainly attributed to the direct feedback it provided and its ease of use. Technical problems with the smartphone interface intermittently occurred (e.g. Bluetooth connection/requests for automatic updates). In addition, coaches reported that a minority of patients felt the smartphone application lacked variation. Considering future long-term use, coaches proposed a more individualised technical training based on individual patient needs (e.g. more extensive in patients with difficulties and those needing more contact time). Finally, the coaches regretted that the home exercises did not result in higher step counts and lacked variation, which might explain the low use of the home exercise booklet by patients.

Actual usage

Almost sixty percent (59.7%, 95/159) of patients wore the step counter for more than 90% of the days they were included in the coaching program, representing a median [P25-P75] 6.3 [5.8-6.8] days.week^{-1} with no difference over time (p=0.98). Actual usage of the different smartphone application tasks is outlined in Table 3. Actual usage decreased significantly over time for all tasks (p<0.001 for all) except for the weekly feedback task (p=0.14). More specifically, actual usage of the daily goal, sending activity and daily feedback tasks decreased from respectively 5 [3 to 7], 5 [2.5 to 6] and 3 [1 to 5] days per week at the start of the intervention to 4 [1.5 to 6.5], 3.5 [0.5 to 6.0] and 2 [0 to 4.5] days per week at the end of the trial (p<0.001 for all). Actual usage did not differ between younger and older patients nor between male and female patients (Multimedia Appendix 9).

In terms of self-reported actual usage, a large majority of the patients (76.7%, 122/159) stated that they looked "several times per day" at their step counter. Only 22.0% (35/159) of patients claimed to perform their home exercise at least on a daily basis and one-third stated they had "never" performed these exercises.

Coaches performed 1053 out of the 1161 contacts that appeared on the platform, however, no details on the time of solving the tasks were available.

Table 3. Overview of the different components of the intervention. Definition of actual usage of the different components of the intervention of all completers (n=159 patients), the minimum and maximum values one can achieve in terms of actual usage (reported when applicable).

	Actual usage		
Components of the intervention	**Definition of actual usage**	**Median [p25-p75][a]**	**Possible Min –Max**
1) One-to-one interview with coach discussing	NA	NA	NA

motivation, barriers, favorite activities and strategies to become more active			
2) Step counter (Fitbug Air©)	A day with ≥70 steps recorded	6.3 [5.8-6.8]	0-7
3) A project-tailored smartphone coaching application (Linkcare, Barcelona ES) with different tasks:			
- Send activity data (days/week)	Patient closes task	4.1 [2.4-5.6]	0-7
- Looking to the daily goal (days/week)	Patient closes task	4.1 [2.1-5.9]	0-7
- Looking at the daily feedback (days/week)	Patient closes task	2.2 [0.7-4.1]	0-6
- Looking at the weekly feedback (% of weeks in the intervention)	Patient closes task	55 [29-78]	0-100
4) A booklet containing home exercises	NA	NA	NA
5) Weekly group text messages with activity proposals sent by the coach	NA	NA	NA
6) Contact with the coaches which was triggered in the case of non- actual usage with wearing the step counter, failure to transmit data or failure to progress.	NA	NA	NA

[a]25th and 75th percentiles [P25-P75]

Feasibility

Feasibility from the perspective of the patients was good as a large proportion of patients reported that the smartphone intervention was not too much of a burden to work with when they were asked how they had experienced the technical aspects of the intervention. Coaches spent significantly more time (p=0.002) interacting with the first 10 of their patients compared to the ones who were recruited at a later stage in their center (See Figure 4). These findings were confirmed when the arbitrarily chosen cut-off point of comparing the first 10 patients was changed to the first 8 or 12 patients.

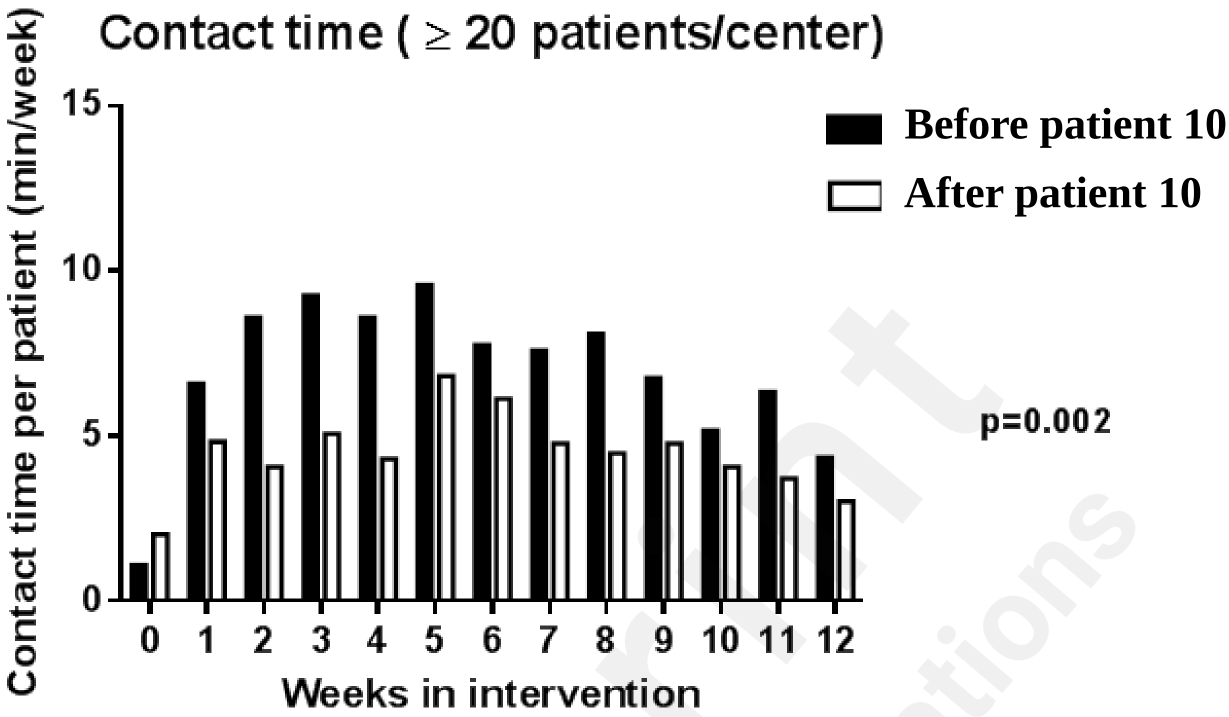


Figure 4. Contact time throughout the intervention (only including centers with more than 20 patients). The black bars represent the mean contact time (in minutes/week) per patient from the first 10 patients that were recruited in each center. White bars represent the mean contact time (in minutes/week) per patient from the patients that were recruited at a later stage. P-value indicates difference between the total cumulated contact time over the 12 weeks between patients recruited in early stage vs later stage.

All PA coaches present in the focus group reached consensus that a follow-up of approximately 25-30 patients simultaneously for one coach would be feasible. It was felt to be beneficial to have one coordinating centre to discuss day-to-day problems in patient management on a case-by-case approach.

Association of Actual usage & Feasibility with the Effectiveness of the Intervention

Patients in the low (n=49), medium (n=46) and high (n=45) (group) contact time group had a median [(P25-P75)] total contact time of respectively 25 [10 - 30], 50 [40 - 60] and 140 [105 - 185] minutes.

Patients who had more contact time with the coaches during the time of the study, had more severe airflow obstruction, tended to have a lower functional exercise capacity (Table 4) and had a significant smaller increase in PA, also after adjusting for covariates (age, baseline FEV_1 (%predicted), baseline 6MWD, baseline mMRC-score and the number of acute exacerbations in the last 12 months (p-for-trend=0.01)) (Figure 5). The latter findings were confirmed when contact time was treated as a continuous variable (cfr. Multimedia Appendix 7).

Table 4. Patient baseline characteristics according to the total contact time (only including patients with valid PA measurement; n=140); data are expressed as mean (Standard Deviation). P-value indicates differences between the 3 contact time groups.

Variables	**Low contact time (n[d]=49)**	**Medium contact time (n=46)**	**High contact time (n=45)**	**p-value**
Age (years), mean (SD[e])	65 (7)	65 (10)	68 ± 6)	0.16
Female/male, n (%)	28 (57) / 21 (43)	34 (74) / 12 (26)	27 (60) / 18 (40)	0.20
BMI[f] (kg/m^2), mean (SD)	27.8 (5.3)	26.1 (4.4)	27.0 (6.4)	0.35
FEV_1[g] predicted (%), mean (SD)	59.5 (22.6)	54.1 (16.5)	49.1 (20.5)[c]	0.04
6MWD[h] (m), mean (SD)	444 (100)	459 (101)	411 (113)	0.09
6MWD predicted (%), mean (SD)	71.5 (14.5)	71.2 (15.0)	67.4 (19.6)	0.29
CAT-score[i], median [p25-p75][j]	10 [6 to 17]	13 [7 to 19]	16 [10 to 21]	0.11
Quadriceps Force[k](kg), mean (SD)	33.1 (13.2)	31.2 (10.0)	29.2 (10.5)	0.33
PA[l] (steps/day), median [p25-p75]	4542 [3387 to 5587]	4377 [3016 to 6723]	3186 [2375 to 5339]	0.15
Contact time W4[m]	0 [0 to 5][a]	10 [5 to 20][b]	50 [20 to 85][c]	0.005

(min), median [p25-p75][l]	

[a]indicates statistical significance (p<0.05) between low vs medium contact time groups
[b]indicates statistical significance (p<0.05) between medium vs high contact time groups
[c]indicates statistical significance (p<0.05) between low vs high contact time groups
[d]number of patients
[e]Standard Deviation
[f]Body Mass Index (BMI) in kilogram/meters^2
[g]Forced Expiratory Volume in one second (FEV_1) in % predicted
[h]Six Minute Walk Distance (6MWD) in meters. 6MWD was missing in 2 patients
[i]COPD assessment test (CAT)
[j]25th and 75th percentiles [P25-P75]
[k]Quadriceps Force (QF) in kilograms. QF was not measured in 2 centers and QF was missing in 27 patients
[l]PA, Physical Activity (PA) in steps/day
[m]Week 4 (W4) in minutes

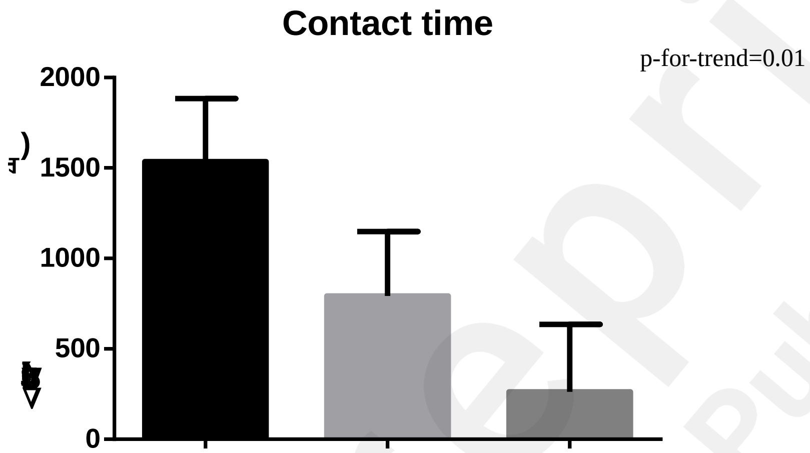


Figure 5. Change in PA (mean ± standard error) across groups of patients according to total conta
adjusted for age, baseline functional exercise capacity, baseline forced expiratory volume in 1 second,
symptom score (mMRC), number of acute exacerbations in the previous 12 months. Data are b
Actigraph measurements and include 140 patients. P-value (p for trend) indicates difference in inte
effect between patients divided based on contact time groups.

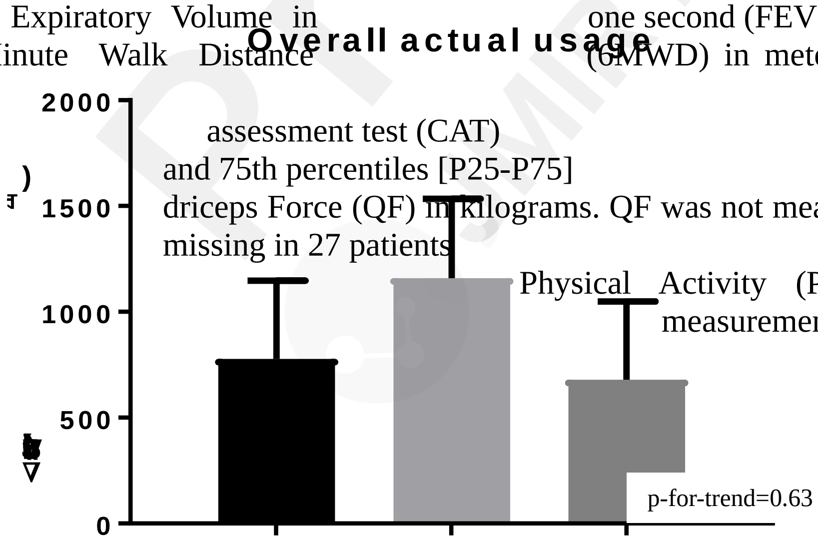
W[redacted]d in 3 groups according to their overall actual usage score, neither patient characteristics nor effectiveness were different (see Table **; Figure 6**). The latter findings were confirmed when actual usage score was treated as a continuous variable (sensitivity analyses in Multimedia Appendix 7).

Table 5. Patient characteristics according to the total actual usage score (3 groups only including patients with

valid PA measurement by actigraph; n=140); data are expressed as mean ±(Standard Deviation). P-value indicates differences between the 3 actual usage groups.

Variables	**Low actual usage (<47% of usage) (n[a]=47)**	**Medium actual usage (47%-75% of usage) (n=46)**	**High actual usage (>75% of usage) (n=47)**	**P-value**
Age (years), mean (SD[b])	66 (8)	66 (9)	65 (8)	0.76
Male/Female, mean (SD)	31 (66) / 16 (34)	29 (63) / 17 (37)	29 (62) / 18 (38)	0.91
BMI[c] ($kg.m^{-2}$), mean (SD)	27.5 (5.3)	27.6 (6.5)	26.0 (4.3)	0.34
FEV_1[d] predicted (%), mean (SD)	54.4 (20.3)	55.2 (19.5)	53.5 (21.6)	0.92
6MWD[e] (m), mean (SD)	431 (106)	432 (105)	454 (107)	0.50
6MWD predicted (%), mean (SD)	69 (17)	69 (17)	72 (16)	0.61
CAT[f] (score), median [p25-p75][g]	14 [7 to 19]	13 [6 to 19]	12 [7 to 21]	0.94
QF[h] (kg), mean (SD)	32.0 (10.8)	30.0 (12.9)	31.1 (9.4)	0.73
PA[j] (steps/day) median [p25-p75]	4369 [2868 to 5672]	3850 [2380 to 6108]	4540 [2940-6731]	0.49

[a]number of patients
[b]Standard Deviation
[c]Body Mass Index (BMI) in kilogram/meters^2
[d]Forced Expiratory Volume in one second (FEV_1) in % predicted
[e]Six Minute Walk Distance (6MWD) in meters. 6MWD was missing in 2 patients
[f]COPD assessment test (CAT)
[g]25th and 75th percentiles [P25-P75]
[h]Quadriceps Force (QF) in kilograms. QF was not measured in 2 centers and QF was missing in 27 patients
[j]PA, Physical Activity (PA) in steps/day, valid PA measurements was present in 140 patients.



[redacted]

Figure 6. Change in PA (mean ± standard error) across groups of patients according to overall actual usage score; adjusted for age, baseline functional exercise capacity, baseline forced expiratory volume in 1 second, baseline symptom score (mMRC), number of acute exacerbations in the previous 12 months. Data are based on Actigraph measurements and include 140 patients. P-value (p for trend) indicates difference in intervention effect between respectively patients divided based total actual usage score.

Logistic univariate regression analysis revealed that patients with a low contact time (≤30 minutes) (n=103) after 4 weeks were 3.58 times more likely of achieving the MID improvement of 1000 steps/day ([95%CI] [1.88 – 6.82] (p<0.0001) compared to patients with more contact time.

Discussion

Principal Results

Based on secondary analysis of the MrPAPP PA telecoaching trial in patients with COPD, the present mixed design study shows that the intervention was feasible and well accepted by both patients and coaches. Given the design of the intervention, (i.e. patients were contacted when PA was not increasing) patients whose PA increased less had higher contact time with coaches, suggesting that the high contact time resulted from either difficulty or reluctance to engage in PA. Furthermore, we observed that the overall level of actual usage with the program components in the entire group did not influence the intervention effect.

The intervention had good acceptability for patients who rated their satisfaction in line with previous PA telecoaching research in a mixed COPD and diabetes type 2 population [25]. Higher acceptability scores might result in a higher chance of patients having more actual usage of the intervention. This was the case for the high ratings of the step counter by the patients, which was translated into excellent actual usage of the step counter throughout the trial. These high actual usage scores are in line with previous studies [7,9,13,14]. As the step counter was used as the medium to coach patients in this trial, we a priori chose steps/day as primary outcome of the effectiveness of the intervention, which is in line with the initial trial report of the MrPAPP trial [6]. However, one should note that PA encompasses not only amount (e.g. steps/day) but also intensity (e.g. time spent in moderate to vigorous PA) and time spent in different postures.

The smartphone application was also well received by patients, although to a lesser extent than the step counter. This was associated with a considerably lower actual usage score of patients for the smartphone intervention compared to the step counter. Several factors may explain this relatively lower actual usage. Firstly, a low proportion of patients with COPD who owned a smartphone prior to the study might have caused less fluency with the smartphone (‘low smartphone literacy’), leading to technical problems and discouraging smartphone use. Unfortunately, we do not have information on smartphone literacy at baseline. Furthermore, the actual usage rate of the smartphone tasks decreased over time. This was against our expectations, as one would expect that patients who have low smartphone literacy at the start of the trial (mostly those without a smartphone of their own) would increase their actual usage over time as they learn to operate the smartphone better. The latter learning effect was often catalysed via the help of patient’s relative (e.g. (grand)-children or spouse) and via the study team as reported by patients during the interviews. Secondly, findings from the semi-structured interview revealed that patients felt the interaction with the application was often hindered due to Bluetooth and internet connection issues. Especially, the process of sending the step count data with the smartphone was perceived to be time consuming. This might have caused frustrations among patients, which could have initiated a decline of actual usage of the smartphone. Thirdly, findings from the focus group and patients interviews revealed that patients felt the content of the smartphone application lacked variation (e.g. daily repetition of morning messages with the same weekly goal). It presents another probable reason on why actual usage of the smartphone application was rather low and decreased over the 3 months of the trial. This could perhaps be improved by implementing components of gamification [26].

In literature, mixed results and high heterogeneity are reported on the actual usage with PA coaching web portals or smartphone applications. During a 4 months, internet-based PA telecoaching program, veterans with COPD logged into the website and uploaded their daily step counts for 5.7 days per month which decreased to 3.0 days per month over a follow-up of 12 months [7,27]. Of note, the web portal in this trial was not intended for daily use with a recommended frequency of 4 logins per month. The low degree of actual usage over a longer follow-up time was confirmed by a 9 months home-based pilot study, in which a smartphone-based activity coach was rarely used (only on 29 days throughout the whole trial) [28]. However, no information was provided on the change in actual usage over time in this trial [28]. Components of the intervention that were not individually tailored (e.g. educational activity tips and home exercise booklet) were rated as less useful. This confirms patients' self-reported actual usage of the home exercise booklet, which was low and is in line with findings from the focus group, in which PA coaches pointed out that the home exercise booklet was not individualized for each specific patient. This highlights the importance of introducing personalized components within PA telecoaching which has also been suggested in patients with ischemic heart disease who participated in a mobile health cardiac rehabilitation intervention [29,30]. In line with the patients, the coaches expressed good acceptability of the current PA telecoaching program. On future use of the intervention, coaches reached the following consensus:

1) "The goal of such a PA telecoaching intervention should be that patients are able to use this intervention quasi independently indefinitely. Every 6 months patients could come for a follow-up visit, synchronized with other planned health visits to the outpatient clinic." Interestingly, our data suggest that three months of coaching might be enough for patients to reach a plateau in PA increase (see Multimedia appendix 10).

2) "As their PA coach it is our task to provide further follow-up by giving them the step counter and occasional phone calls for follow-up." Such strategies merit further validation, but the statement strengthens the importance of acceptability, actual usage and feasibility with long-term PA

telecoaching programs in this patient population. In addition to the latter perspectives, the coaches highlighted that it is highly important that the preferences and experiences of the patients with the intervention are assessed and taken into account when looking at future implementation. Therefore, future (long-term) PA telecoaching interventions need to ensure whether enough variation within such applications is introduced in addition to those components deemed as the most essential to patients (i.e. step counter and contact with the study team). Furthermore, such interventions need to take the occurrence of acute exacerbations into account and involve patient's relatives as these can play an important role as social support in being physically active [31], which was supported by the analyses of the interview data. Focusing on introducing new daily PA routines can provide a good starting point for long-term PA improvement according to the latter.

In terms of coach feasibility, the main paper of the MrPAPP trial revealed that patients were contacted for a median of 50 minutes throughout the 12 weeks intervention [6]. Translated into socio-economic terms, this means that coaching 25 patients simultaneously corresponds to approximately 2 hours/week for one PA coach. This number might even decrease as the coach accumulates his/her expertise/problem-solving efficiency, resulting in a lower burden.

Literature about the relationship of both actual usage by the patients and coach feasibility (contact time) of the intervention with the change in PA in telecoaching trials is scarce. In the present study, the degree of the overall actual usage score (including wearing the step counter and all the application tasks) was not associated with the effectiveness of the intervention. This is in contrast to a 4-week pilot (telecoaching) study which showed a positive relationship between the degree of actual usage of wearing a smartphone-based activity coach and the benefits from the intervention during the first two weeks albeit this association disappearing during the third week [13]. Next to actual usage of the intervention by patients, actual usage by coaches is also crucial to how the intervention is delivered. Despite a high degree of actual usage of the PA telecoaching program by patients in the trial by Vorrink and colleagues (i.e. 89.0% of the days used) [32], the program was not able to induce significant improvements in PA [9]. The latter might be partly explained by the lack of feasibility from the part of the coaches. Due to financial reasons and time constraints, there was a low degree of actual usage of the primary care physiotherapists in using the foreseen website to adjust the patient's PA goals and to send motivating messages to the patients. In the present trial, actual usage of the coaches could not be assessed in depth as we did not have information on the exact timing when coaches solved the tasks. The latter could have influenced the effectiveness of the intervention. However, the automated goal calculation/adjustment in our intervention could have partly limited the impact on the effectiveness of the intervention in comparison to the trial of Vorrink and colleagues. This highlights the importance of introducing (semi-) automated components in such interventions.

In contrast to actual usage, the contact time between the coach and patients was associated with the effectiveness of the intervention, i.e. a lower effect in those patients in need of more contact time. These patients were the more severe (i.e. they have more severe airflow obstruction and tend to have a lower functional exercise capacity) and are more likely to experience exacerbations and therefore have more chance of triggering coaching-related and/or health-related contacts with their coach. Since contact time remained a significant, negative predictor of the change in PA, independent of the patient characteristics, this may point to the inability of some patients to work with the coaching application. This corroborates with the findings of the qualitative part of the study and should not be ignored as a reason for treatment failure. In clinical practice, we would therefore advocate flexible use of these interventions where patients are diverted to other interventions (e.g. more supervised exercise programs) if contact time accumulates. This is important for stratification in future trials.

Strengths and Limitations

To the best of our knowledge, the present study is the first providing an in depth analysis of the acceptability, actual usage and feasibility with a PA telecoaching intervention developed for patients with COPD. Our study is unique as it allows us to investigate these aspects, relating them to physiological characteristics along with the level of response.

The present results are based on a combination of quantitative and qualitative research, including information coming from patients as well as from coaches. In addition, the study is performed on the back of a properly powered randomized controlled trial, which was characterized by a comprehensive physiological assessment and objective assessment of PA. Furthermore, the current PA telecoaching intervention consists of several behavioural principles (including but not limited to facilitating goal setting, action planning, feedback, problem solving) which were based on the behaviour change technique taxonomy of Michie and colleagues [33]. Nevertheless, some limitations need to be considered.

First, we only included patients that completed the trial. This could have resulted in a selection bias. Coaches might have spent more time in those patients who subsequently dropped out during their intervention period. However, since only 7.0% (12/171) of patients discontinued, this is unlikely to have had a large impact on the results. Second, no multiple-comparison post-hoc corrections were applied in the quantitative data-analysis as these analyses should be regarded as exploratory and in need of independent confirmation. These results help to guide future research, however, they may not be taken as a final judgement and should be interpreted with caution due to the latter limitation.

Third, only one focus group with a limited number of PA coaches was performed. Therefore, data saturation could not have been reached. Another focus group with participants with a broad background and experience would have been of great value for A) external validity of findings and B) to ensure data saturation. Nevertheless, coaches were asked during the focus group whether they had additional comments. In addition, a summary of the focus group was sent to the coaches who could not be present at the focus group for completion of the summary. New themes emerged, which allowed for more data capturing. Fourth, we did not specifically assess capabilities/history of patients with managing the smartphone device or their expectations. In hindsight, this might have provided even more detailed information in order to predict the therapeutic response to the PA telecoaching intervention. Fifth, for the assessment of acceptability of the intervention we used a project-tailored questionnaire. In literature, several attempts have been made to measure the quality of mHealth apps, however no measure from a user perspective has been widely accepted [34–36]. Incorporating methodologies as proposed within the Human Computer Interaction research and tools such as the Mobile App Rating Scale (MARS) and uMARS (User version) tools (which were not available at the time of trial initialization) would have strengthened the development and validity of the acceptability assessments in the present manuscript [37,38]. Nevertheless, the findings of our project-tailored questionnaire still provide interesting insights into the acceptability with these kinds of interventions. Sixth, as proposed by the Medical Research Council, a process evaluation incorporates 3 themes (i.e. implementation, mechanisms of impact and context) [5]. The concepts of 'implementation' and 'mechanisms of impact' are largely covered in this manuscript by the assessments of actual usage, feasibility and acceptability as well by their association with the effectiveness of the intervention. However, we were not able to evaluate the 'context' theme (i.e. how external factors had an impact on our intervention) in depth in present study. Seventh, as the cut-offs for making tertiles for contact time and actual usage score were driven by the data collected in this trial, they should not be regarded as clinically important cut-off points despite the wide range of contact time and actual usage scores presented in the current manuscript. Finally, future research should investigate whether a feature for social interactions amongst peers might further lower the burden on health care providers. Such peer support has also been integrated as a catalyst for behaviour change in the taxonomy of Michie and colleagues given that privacy of patients is not breached [26,33].

Clinical Importance

In line with general findings of the present behavioural modification program [6], this paper shows that PA telecoaching is not an intervention to which all patients respond, but it is feasible and well received by the vast majority of patients. The number of smartphone users is increasing worldwide [39]. Given that it requires only modest health care resources and is relatively less time-consuming compared to one-to-one PA counselling, PA telecoaching does have opportunities for future implementation. Furthermore, the use of an electronic communication strategy might lower the burden on both clinicians and patients as we found a relatively low contact time of 50 minutes over 3 months of coaching. In addition, it offers the possibility of coaching people from a distance [3]. The theoretical framework and proven effectiveness of the current intervention also provides opportunities for its use in other elderly populations who are in need of being coached towards a more active lifestyle. In addition, findings of this paper provide possible guidance for the selection of patients that will benefit the most from these types of interventions. Patients with very limited exercise capacity, more symptoms, GOLD quadrants C or D and/or a high amount of contact time during the first 4 weeks of the program are less likely to improve [6]. In these patients further coaching input may be futile and other more intensive face-to-face interventions should be considered.

Conclusion

This 12-week PA telecoaching intervention was well accepted and feasible for both patients with COPD and their coaches. Actual usage of the step counter was excellent, while actual usage of the smartphone tasks was lower and decreased over time. Overall, actual usage was not associated with the effect of the intervention. The step counter and direct contact with the coach were perceived as the most useful components of the intervention by the patients. Patients with more need for contact had more severe airflow obstruction, tended to have more severely limited exercise capacity and experienced less PA benefits. Alternative strategies (including more face-to-face contacts and offering pulmonary rehabilitation programs) might be more effective in these patients.

Acknowledgements

The authors would like to acknowledge Claudia Perez for providing data from the Linkcare application and Maarten Spruit (MS) for his contribution with the data collection.

Details of contribution

RR, HD, ZL, AF, CdJ, IV, JGA, MIP, MS, RT, CY and TT contributed to the study protocol and development of the intervention. ML, RR, HD, ZL, RT, NR, AF, Cdj, SB, GB, AS, and IV contributed to the data collection. ML, HD, and TT contributed to the data analyses and interpretation of the data. ML, HD and TT contributed to the writing of the manuscript. RR, HD, ZL, RT, NR, AF, Cdj, EGS, FMR, SB, NH, GB, AS, IS, IV, JGA, MP and TT critically reviewed the manuscript. TT is the guarantor of the study. All authors had full access to all the data in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

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Funding statement

The PROactive project is funded by the Innovative Medicines Initiative Joint Undertaking (IMU JU) #115011. The Leuven study group was supported by the Flemish Research Foundation (grant # G.0871.13). HD was the recipient of a joint ERS/SEPAR Fellowship (LTRF 2015) and is a post-doctoral fellow of the FWO-Flanders. ZL was the recipient of a European Respiratory Society Fellowship, grant number LTRF 2016-6686 and is a post-doctoral fellow of the FWO-Flanders (Fellowship number 12U5618N). FR is funded by The National Council for Scientific and Technological Development (CNPq), Brazil (249579/2013-8). The Zurich study group was supported by an additional grant of the Lung League Aargau (non-profit organization) as well as by Swisscom AG who provided 30 sim cards and data usage of up to 1 GB per month. MP's contribution to this work was supported by the NIHR Respiratory Biomedical Research Unit at the Royal Brompton and Harefield NHS Foundation Trust and Imperial College, London UK who part fund his salary. The views expressed in this publication are those of the authors and not necessarily those of the NHS, The National Institute for Health Research or the Department of Health. The sponsors did not have any influence on the design, conduct and analysis of the study. ISGlobal is a member of the CERCA Programme, Generalitat de Catalunya.

Conflict of interest

None declared.

Ethics approval:

This study was approved by the local ethics committee at each centre (Commissie medische ethiek van de universitaire ziekenhuizen KU Leuven (Leuven, S-55919); Medische ethische toetsingscommissie universitair medisch centrum Groningen (Groningen, Metc 2013.362); RES Committee London—South East (London and Edinburgh, 13/LO/1660); Scientific Council of the 'Sotiria' General Hospital for Chest Diseases (Athens, 27852/7-10-13); Kantonale Ethikkommission Zürich and Ethikkommission Nordwest- und Zentralschweiz (Zurich, KEK-ZH-Nr. 2013-0469 and EKNZ2014-192, respectively)).

Multimedia Appendix 1

Home exercise booklet.

Multimedia Appendix 2

Powerpoint file containing additional screenshots and slides.

Multimedia Appendix 3

Project-tailored user-experience questionnaire.

Multimedia Appendix 4

Patient interview: discussion guide.

Multimedia Appendix 5

Focus group: interview coaches.

Multimedia Appendix 6

Patient interview: COREQ questionnaire.

Multimedia Appendix 7

Sensitivity analysis with contact time and actual usage as continuous variables.

Multimedia Appendix 8

Illustrative quotes of thematic analysis.

Multimedia Appendix 9

Actual usage with the different components of the intervention according to age and gender.

Multimedia Appendix 10

Step counter (fitbug) steps throughout the trial in patients who completed the intervention.

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Abbreviations

6MWD: six minute walking distance

COPD: chronic obstructive pulmonary disease

FEV_1: forced expiratory value in 1 second

MID: minimal important difference

mMRC scale: modified Medical Research Council scale

n: number

NCT: National Clinical Trial

PA: physical activity

SAS: Statistical Analysis Software

SD: standard deviation

SE: standard error

V: visit

WWW: World Wide Web