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REVIEW

Telehealthcare in COPD: A systematic review and meta-analysis on physical outcomes and dyspnea☆

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Telemedicine;
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Summary
Background: Only a minority of patients with chronic obstructive pulmonary disease (COPD) have access to pulmonary rehabilitation (PR). Home-based solutions such as telehealthcare, have been used in efforts to make PR more available. The aim of this systematic review was to investigate the effects of telehealthcare on physical activity level, physical capacity and dyspnea in patients with COPD, and to describe the interventions used.
Methods: Randomized controlled trials were identified through database searches, reference lists and included authors. Articles were reviewed based on eligibility criteria by three authors. Risk of bias was assessed by two authors. Standardized mean differences (SMD) or mean differences (MD) with 95% CI were calculated. Forest plots were used to present data visually.
Results: Nine studies (982 patients) were included. For physical activity level, there was a significant effect favoring telehealthcare (MD, 64.7 min; 95% CI, 54.4–74.9). No difference between groups was found for physical capacity (MD, −1.3 m; 95% CI, −8.1–5.5) and dyspnea (SMD, 0.088; 95% CI, −0.056–0.233). Telehealthcare was promoted through phone calls, websites or mobile phones, often combined with education and/or exercise training. Comparators were ordinary care, exercise training and/or education.
Conclusions: The use of telehealthcare may lead to improvements in physical activity level,

Abbreviations: 6MWT, 6-min walk test; ADL, activities of daily living; C, comparator; CI, confidence interval; COPD, chronic obstructive pulmonary disease; CRQ-D, chronic respiratory questionnaire, dyspnea subscale; ESWT, endurance shuttle walk test; FEV_1, forced expiratory volume in 1 s; FVC, forced vital capacity; ITT, incremental treadmill test; MD, mean difference; MRC, Medical Research Council; PR, pulmonary rehabilitation; RCT, randomized controlled trial; SMD, standardized mean difference; SOBQ, shortness of breath questionnaire; THC, telehealthcare.
☆ Prior abstract publication/presentation: An abstract for this study has been accepted for presentation at the ERS International Congress 2014.

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although the results should be interpreted with caution given the heterogeneity in studies. This is an important area of research and further studies of the effect of telehealthcare for patients with COPD would be beneficial.

Registration: In PROSPERO 2012: CRD42012003294. Study protocol: http://www.crd.york.ac.uk/PROSPEROFILES/3294_PROTOCOL_20121016.pdf.

Contents

Introduction

Decreased physical capacity and dyspnea are common symptoms in patients with chronic obstructive pulmonary disease (COPD) [1]. They also show a reduced level of physical activity compared to healthy controls [2]. Since it has emerged that reduced physical activity levels increases the risk for all-cause death in patients with COPD [3], it is essential to find ways to increase their physical activity levels.

Pulmonary rehabilitation (PR) including exercise training is proven to have positive effects on physical capacity, quality of life and health status among patients with COPD [4–6]. However, the effect on physical activity level after the rehabilitation period is inconsistent [6–8]. Furthermore, only a limited number of patients with COPD have access to PR [9–12].

Since transportation has been reported as the most common barrier to participation in PR [12,13], home-based solutions could be used to make PR more available. Telehealthcare is one possible option that has gained in interest lately [6]. Patients with COPD have reported counseling via telephone as valuable and an aid in developing strategies for behavioral changes and increasing motivation to maintain those changes [14].

In this systematic review, we have defined telehealthcare as: "the use of electronic information and communications technologies to provide and support health care when distance separates the participants" [15]. In telehealthcare, the following criteria have been defined [16]:

- The information (delivery of health services) is transmitted electronically over a distance
- The information can be, for example, voice, sounds, video, pictures or text
- The transmission can be asynchronous (store-and-forward applications) or synchronous (e.g. two-way video consultations)

There is moderate evidence that the use of telehealthcare for patients with COPD increases quality of life and decreases hospital admissions and emergency department visits compared to ordinary care [17,18]. The effect on mortality and patient satisfaction is inconsistent [17,18]. Home-based telehealthcare for patients with chronic diseases also tends to reduce health care costs [19]. In previous systematic reviews, the interventions in the included studies have varied considerably.

To our knowledge, there has not been any previous systematic evaluation of the effect of telehealthcare on physical activity level, physical capacity or dyspnea in patients with COPD.

The aim of this systematic review and meta-analysis was to investigate the effects of home-based telehealthcare on physical activity level, physical capacity and dyspnea in patients with COPD, as well as to describe how these telehealthcare interventions have been designed.

Materials and methods

The methodology was in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) [20]. The review was registered in PROSPERO 2012: CRD42012003294. The study protocol is available at http://www.crd.york.ac.uk/PROSPEROFILES/3294_PROTOCOL_20121016.pdf.

Since more randomized controlled trials (RCTs) than expected were found, two changes from the protocol have been made: only RCT studies were included and a meta-analysis was performed.

Eligibility criteria

Peer-reviewed RCTs with available full text, published in English were included. There was no restriction in publication year.

The studies had to meet the following criteria to be included:

- Participants: ≥40 years, diagnosed with COPD according to Global Initiative for Chronic Obstructive Lung Disease (GOLD) [21], the European Respiratory Society [22], the American Thoracic Society [23,24], or the British Thoracic Society [25]. In studies addressing several diagnoses, the results for patients with COPD had to be separately evaluated.
- Interventions: The major part (in length of time or number of contacts) could be classified as home-based telehealthcare. Some kind of feedback, motivational element, or counseling had to be provided to the patient through telehealthcare at least three times during the first three months.
- Comparator: Any kind of comparator.
- Outcome measures: Physical activity level (objectively or questionnaires), physical capacity (objectively), or dyspnea (questionnaires or scales) had been measured before and after intervention and (when applicable) at follow-up.

Search strategy and risk of bias

Studies were identified through searches (inception to August 30, 2013) in the Cochrane Central Register of Controlled Trials (CENTRAL), PubMed, CINAHL, AMED, PsycINFO, Web of Science, Scopus and PEDro. To increase sensitivity a broad search strategy (Appendix A1—A3) was developed by the authors and supported by the search coordinators of the Cochrane Airways Group. For included studies, the "related citations" function in PubMed was used, reference lists were searched, and authors were asked for knowledge of additional articles.

At the start, one author (SL) screened all titles and excluded articles that were obviously irrelevant. Thereafter, three authors (SL, KW and ÅH) used a standardized form based on eligibility criteria to independently review abstracts and exclude irrelevant articles. Finally, the same three authors independently reviewed the full texts, and articles not meeting eligibility criteria were excluded. Possible disagreement during the review of full texts was solved by a majority decision.

Data was extracted using a standardized form based on the Cochrane checklist of items to consider in data extraction [26]. Additionally, items to identify multiple reports from the same study [26] were extracted. Authors of the included studies were contacted by email to clarify any unclear information, and to obtain data for the meta-analysis, if needed.

The Cochrane risk of bias tool [26] was used to assess risk of bias. Each domain was rated as "low risk", "high risk" or "unclear risk" independently by two authors (SL and BR) in an unblinded manner. If consensus could not be reached, a third researcher (KW) was involved, and a majority decision was made.

Data analysis

Data was combined using Comprehensive Meta-Analysis (CMA) software by two authors (AN and SL). I^2 statistics was used to examine heterogeneity amongst individual studies. For analyses with $I^2 > 60\%$ outliers were excluded from the meta-analysis due to heterogeneity (the study with the most outlying result first), until $I^2 < 60\%$, as recommended [26]. Following strategies were also used to decrease the impact of heterogeneity [26]: effect measure was changed to standardized mean difference (SMD) for analyses with different measurements, sensitivity analyses were performed and presented and random-effects model was used if $I^2 > 30\%$, otherwise, fixed-effects model was applied. For the study with multiple intervention groups, the comparator group was divided as recommended [26]. Differences were expressed as SMD or mean difference (MD), with corresponding 95% confidence intervals (CI). Data were synthesized into forest plots, and publication bias was assessed statistically using Egger's test. $P < 0.05$ was considered statistically significant.

Results

The broad search strategy used in this systematic review resulted in 15,574 potentially relevant articles. A total of 597 abstracts and 132 full texts were chosen for review and nine studies met inclusion criteria [27—35] (Fig. 1). The first agreement between assessors in the decision of inclusion and exclusion of studies was 91%. After discussion, agreement was 100%.

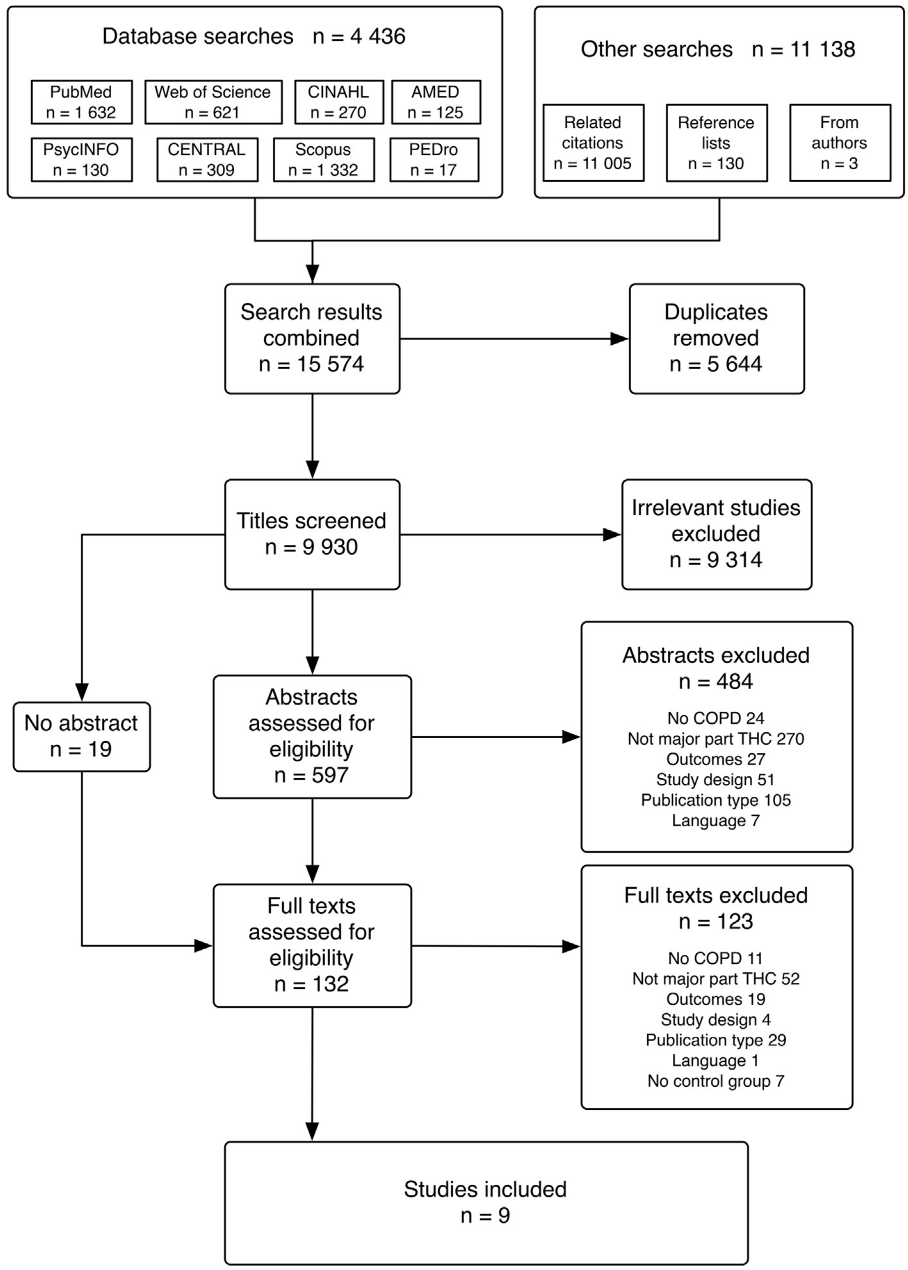

Figure 1 Flow chart of study selection process. Abbreviations: COPD = chronic obstructive pulmonary disease; THC = telehealthcare.

Study characteristics

Characteristics of the included studies are presented in Table 1.

The included studies analyzed a total of 982 patients (34% women) with COPD. The mean forced expiratory volume in 1 s (FEV_1) in % of the predicted value presented ranged from 34 to 56 [28,30–34], in other words, moderate to severe COPD [21]. The inclusion and exclusion criteria used in the included studies are presented in Appendix B.

All studies were judged to have a high risk of bias in at least two domains (Table 2 and Appendix C). Six studies presented approved randomization procedures [27,29,31,32,34,35], and five presented allocation concealment [30–32,34,35]. No study reported blinding of participants and personnel, but four studies reported blinding of outcome assessors [27,29,30,34]. Five studies included all participants (also dropouts) in analyses [27,30–32,34]. Only one study presented all outcomes that were pre-specified in the registration [35]. One study seemed to be free from other risk of bias [34]. No power analyses were presented in five studies [28–30,32,33], two studies did not reach power [27,31], and one study recalculated power during the study [35]. There was an uneven distribution between men and women in two studies [29,32] and differences between groups at baseline in one study

Table 1 Characteristics of the included studies.

Study	Participants			Telehealthcare group (THC)	Comparator group (C)	Outcomes	Study design	Results
	Sample size	Age (years)	FEV_1 (liter/% predicted)					
Bourbeau, 2003 [27]. Canada	191 patients (45% women), 96 in THC, 95 in C.	THC: 69.4±6.5	THC: 1.00±0.33/—	**Telehealthcare**: Weekly phone calls with follow-up of education for 8 weeks. Then monthly phone calls until 12 months.	Ordinary care	**Physical activity level**: Not reported	RCT	26 dropouts[a] (10 THC, 16 C — included in analyses).
		C: 69.6±7.4	C: 0.98±0.31/—	Case manager available for advice by telephone.		**Physical capacity**: 6MWT	12 months	No changes were seen within or between groups for 6MWT.
				Other: 1-hour self-management education per week for 7-8 weeks. Training at home (1 supervised session) 3 times/week, week 7 — month 12.		**Dyspnea**: Not reported		
Carrieri-Kohlman, 1996 [28]. United States of America	51 patients (51% women), 24 in THC, 27 in C.	THC: 68±7[b]	THC: 0.92±0.25[b]/ 40±11[b]	**Telehealthcare**: Weekly phone calls with reinforcement for walking and dyspnea control for 8 weeks.	Home walking as THC. Weekly phone calls for 8 weeks, about adherence to home walking.	**Physical activity level**: Not reported	RCT	1 dropout (from C — not included in analyses).
		C: 66±9[b]	C: 0.91±0.24[b]/ 36±10[b]	**Other**: Home walking 4 times/week for 8 weeks.	*12 coached treadmill exercise sessions pre-intervention.*	**Physical capacity**: 6MWT	8 weeks	No changes were seen within or between groups for 6MWT or dyspnea.
				12 coached treadmill exercise sessions pre-intervention		**Dyspnea**: CRQ-D, Baseline/ transitional dyspnea index, Visual analogue scale (during exercise), dyspnea index[c]		Dyspnea index decreased significantly in both groups. No difference between groups.
Garcia-Aymerich, 2007 [29]. Spain	113 patients (14% women), 44 in THC, 69 in C.	THC: 72±10[d]	THC: 1.2 (0.8 —1.4)[d]/—	**Telehealthcare:** Weekly phone calls with reinforcing self-management strategies at month 1, one phone call at months 3 and 9.	Ordinary care	**Physical activity level**: Questions about physical activity and regular physical activity	RCT	51 dropouts (23 from THC, 28 from C — not included in analyses).

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Table 1 (*continued*)

Study	Participants			Telehealthcare group (THC)	Comparator group (C)	Outcomes	Study design	Results
	Sample size	Age (years)	FEV_1 (liter/% predicted)					
		C: 73±9[d]	C: 1.0 (0.8−1.5)[d]/—	Access to nurse through web-based call center.		**Physical capacity**: Not reported	12 months	No group difference in either physical activity or regular physical activity at 12 months.
				Other: Assessment at discharge. 2 hours self-management education. Individual care plan. One home visit.		**Dyspnea**: MRC Dyspnea scale		No change in dyspnea within or between groups.
Maltais, 2008 [34]. Canada	252 patients (44% women), 126 in THC1, 126 in THC2.	THC1: 66±9	THC1: 1.13±0.34/46±13	**Telehealthcare:** Weekly phone calls with reinforcement of exercise training for 8 weeks, phone calls every 2 months during months 3−12.	Supervised training 3 times/week for 8 weeks. Encouraged to keep exercising at home 3 times/week during months 3-12. Phone call every 2 months during months 3-12. Reinforcement of exercise training.	**Physical activity level**: Not reported	RCT	36 dropouts (19 from THC1, 17 from C — included in analyses).
		THC2: 66±9	THC2: 1.08±0.39/43±13	Case manager available by telephone.	Case manager available by telephone for advice.	**Physical capacity**: 6MWT, cycling endurance test	12 months	No within- or between-group changes in 6MWT.
				Other: Training at home 3 times/week for 8 weeks.	*Pre-intervention self-management education: 2 lessons/week for 4 weeks.*	**Dyspnea**: CRQ-D		Improvement in both groups in cycling endurance, no group difference.
				Encouraged to keep exercising at home 3 times/week during months 4−12.				Improvements in both groups in dyspnea. No group difference.

				Pre-intervention self-management education: 2 lessons/week for 4 weeks.				
Nguyen, 2009 [30]. United States of America	17 patients (65% women), 8 in THC, 9 in C.	THC: 72±9	THC: −/46.7±18.7	**Telehealthcare:** Daily mobile phone reminders to submit information about symptoms (dyspnea, sputum, cough) and exercise (mode, duration, dyspnea).	Individualized exercise program 3-5 times/week, strategies for self-care, pedometer. Daily reminders to submit information about symptoms and exercise, standard weekly message saying thanks for entering information.	**Physical activity level**: Free-living ambulatory physical activity measured with accelerometer	RCT, pilot study	No dropouts. No significant within-group changes in physical activity level. C had an increase in steps per day compared to THC, which decreased. C increased more than THC at time in moderate to high intensity exercise and peak performance (average steps/min of the best 30 minutes of the day). No change in inactive time
		C: 64±12	C: −/34.4±15	Weekly reinforcement feedback by short text messages or telephone.		**Physical capacity**: 6MWT and incremental cycle ergometer test	6 months	No changes for 6MWT and incremental cycle ergometer test.
				Contacted by nurse in case of worsening of symptoms.				
				Other: Individualized exercise program 3—5 times/week, strategies for self-care, pedometer.		**Dyspnea**: Not reported		
Nguyen, 2013 [31]. United States of America	125 patients (46% women), 43 in THC1, 41 in THC2 and 41 in C.	THC1: 68.5±11	THC1: −/53.3±20.4	**THC1**. **THC2**.	One home visit at start. Monthly face-to-face education unrelated to lung disease.	**Physical activity level**: Questions about frequency and duration of endurance and strengthening exercises for a typical week during the last month.	RCT	17 dropouts (5 from THC1, 6 from THC2 and 6 from C — included in analyses).

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Table 1 (*continued*)

Study	Participants			Telehealthcare group (THC)		Comparator group (C)	Outcomes	Study design	Results
	Sample size	Age (years)	FEV_1 (liter/% predicted)						
		THC2: 68.2±9.9	THC2: −/50.6±18.2	**Telehealthcare**: Individualized web-based education, self-management, exercise and activity plan. Weekly (first month) and biweekly e-mail with reinforcement and feedback. Monthly live chat sessions and bulletin boards for six months. Reporting of symptoms (dyspnea cough, sputum), exercise (mode, duration, dyspnea) and goal-setting over internet. Nurse alerted in case of worsening of symptoms.	**Telehealthcare:** Weekly (first month) and biweekly phone calls with reinforcement, feedback and goal-setting.	Biweekly phone calls with general health information.	**Physical capacity**: 6MWT, ITT, arm endurance	12 months	All groups improved in duration and frequency of endurance exercise and frequency of strength exercise.
		C: 69.3±8.0	C: −/49.4±19.8	**Other:** One home visit at start	**Other**: Individualized education, self-management, exercise and activity plan on paper. Monthly face-to-face meetings at		**Dyspnea**: CRQ-D, Borg scale during and after 6MWT and ITT		THC1 and THC2 improved more in duration of endurance exercise and frequency of strengthening exercise than C. All groups improved in

				medical centers for six months. Weekly reporting of symptoms and exercise in paper diaries				6MWT. No within-group change at ITT. No difference between groups at 6MWT or ITT. THC1 and THC2 performed more arm lifts than C. Improvement of CRQ-D for THC1. No difference between groups at CRQ-D or Borg scale.
Nield, 2012 [32]. United States of America	22 patients (no women), 11 in THC, 11 in C.	THC: 64±8	THC: −/55±16	**Telehealthcare**: Weekly sessions 15−30 min via Skype with feedback on pursed lips breathing and use in daily life.	10 min face-to-face pursed lips breathing education. Daily practice of pursed lips breathing at home.	**Physical activity level**: Not reported	RCT, feasibility study	6 dropouts (2 from THC and 4 from C − included in analyses).
		C: 65±5	C: −/56±12	**Other**: Starting with 10 min face-to-face pursed lips breathing education. Daily practice of pursed lips breathing at home.		**Physical capacity**: 6MWT	4 weeks	6MWT improved in both groups, no difference between groups.
						Dyspnea: SOBQ, Visual analogue scale, Borg scale before and after 6MWT	Follow-up at 12 weeks	No within- or between-group differences in dyspnea.
Oh, 2003 [33]. South Korea	34 patients, only 23 patients presented (39% women), 15 in THC, 8 in C.	THC: 64.8±7.8[d]	THC: −/42.1±15.1[d]	**Telehealthcare**: Telephone calls with discussion of problems and concerns 2 times/week.	One education session	**Physical activity level**: Not reported	RCT	11 dropouts (4 from THC, 7 from C − not included in analyses).
		C: 66.8±12.3[d]	C:−/44.9±17.8[d]	**Other**: One education session, inspiratory muscle training 5 times/day, exercise training, relaxation twice daily.		**Physical capacity**: 6MWT	8 weeks	Distance at 6MWT improved in THC and THC improved more in 6MWT

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Table 1 (*continued*)

Study	Participants			Telehealthcare group (THC)	Comparator group (C)	Outcomes	Study design	Results
	Sample size	Age (years)	FEV_1 (liter/% predicted)					
						Dyspnea: CRQ-D, Borg scale after 6MWT		and dyspnea measured with Borg scale than C. No within or between group differences in CRQ-D.
Waterhouse, 2010 [35]. United Kingdom	240 patients[b] (48% women), 55 in THC1[b], 64 in THC2[b], 56 in C1[b], 65 in C2[b].	THC1: 67.8±8.8[b]	THC1: 1.1±0.5[b]/ —	**Telehealthcare**: Monthly phone calls with encouragement to exercise for 6 months, then at months 9, 12, and 15 months.	Ordinary care.	**Physical activity level**: Not reported	RCT	27 dropouts from baseline (8 from THC1, 8 from THC2, 7 from C1, 4 from C2), 105 dropouts in total from pre-intervention (30 from THC1, 24 from THC2, 20 from C1, 31 from C2). Dropouts not included in the analyses.
		THC2: 69.2±7.8[b]	THC2: 1.1±0.5[b]/ —	**Other**: *Pre-rehabilitation containing community-based versus hospital-based education and exercise.*	*Pre-rehabilitation containing community-based versus hospital-based education and exercise.*	**Physical capacity**: ESWT	18 months	No changes within-group or between-group for ESWT or CRQ-D.
		C1: 69.7±7.8[b]	C1: 1.1±0.4[b]/—			**Dyspnea**: CRQ-D		
		C2: 69±7.3[b]	C2: 1.2±0.5[b]/—					

Abbreviations: 6MWT = 6-minute walk test; C = comparator; CRQ-D = chronic respiratory questionnaire, dyspnea subscale; ESWT = endurance shuttle walk test; FEV_1 = forced expiratory volume in one second; ITT = incremental treadmill test; MRC = medical research council; RCT = randomized controlled trial; SOBQ = shortness of breath questionnaire; THC = telehealthcare

[a] Dropout is defined as subjects who for any reason, fail to complete the trial.
[b] Before pre-intervention.
[c] Dyspnea after 6MWT divided with the distance walked.
[d] Dropouts not presented.

Table 2 Risk of bias in the included studies.

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias	Domains with low risk of bias
Bourbeau, 2003 [27].	☺	?	☹	☺	☺	☹	☹	3/7
Carrieri-Kohlman, 1996 [28].	?	?	?	?	☹	☹	☹	0/7
Garcia-Aymerich, 2007 [29].	☺	?	?	☺	☹	?	☹	2/7
Maltais, 2008 [34].	☺	☺	☹	☺	☺	☹	☺	5/7
Nguyen, 2009 [30].	?	☺	☹	☺	☺	☹	☹	3/7
Nguyen, 2013 [31].	☺	☺	☹	☹	☺	☹	☹	3/7
Nield, 2012 [32].	☺	☺	☹	☹	☺	?	☹	3/7
Oh, 2003 [33].	?	?	?	?	☹	?	☹	0/7
Waterhouse, 2010 [35].	☺	☺	☹	☹	☹	☺	☹	3/7

☺ = low risk of bias
? = unclear risk of bias
☹ = high risk of bias.

[30]. The first agreement between assessors in the decision of risk of bias was 79%. After discussion, the agreement was 96%, and finally, after involving a third author, 100%.

Funding of the included studies are presented in Appendix D.

Physical activity level

Physical activity level was reported in three studies (Table 1) [29–31]. Duration of endurance exercise measured with questionnaires [31] and steps/day measured with accelerometer [30] were selected for the meta-analysis. The study by Garcia-Aymerich et al. [29] was excluded from the meta-analysis due to a dichotomized scale (yes/no) measuring physical activity. The study by Nguyen et al. (2009) [30] was later excluded due to heterogeneity (Table 3), which left only two groups from the same study [31]. The MD for physical activity level was 64.7 min (95% CI, 54.4 to 74.9; $p < 0.001$) favoring telehealthcare (Fig. 2). Egger's test was not applicable due to few studies.

Physical capacity

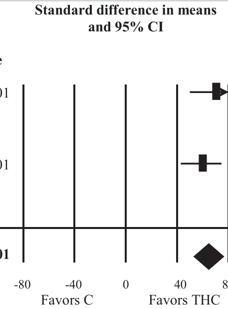
Physical capacity was reported in eight studies (Table 1) [27,28,30–35]. The 6-min walk test (6MWT) [27,28,30–34] was selected for the meta-analysis. The studies by Nguyen et al. (2013) [31] and Oh et al. [33] were later excluded due to heterogeneity (Table 3). No difference between telehealthcare and comparator was found for 6MWT (MD, −1.3 m; 95% CI, −8.1 to 5.5; $p = 0.708$) (Fig. 3). No evidence of publication bias was given by Egger's test ($p = 0.813$).

Table 3 Sensitivity analyses — how exclusion due to heterogeneity affect the results.

	Before exclusion				After exclusion			
	SMD/MD	95% CI	I^2	Number of groups	MD	95% CI	I^2	Number of groups
Physical activity level	−0.081[a]	−0.918 to 0.755	85%	3	**64.7**	**54.4 to 74.9**	**0%**	**2**
Physical capacity	9.2[b]	−2.5 to 21.0	82%	8	−1.3	−8.1 to 5.5	14%	5

Bold numbers indicate a significant result ($p < 0.05$). **Abbreviations:** SMD = standardized mean difference; MD = mean difference; CI = confidence interval.
[a] SMD.
[b] MD.

Study	Comparison	Duration	Outcome	MD (min)	Lower limit	Upper limit	P-value	Weight	Comparator
Nguyen, 2013[31] (a)	THC2 vs C	12 months	Duration of endurance exercise (min/week)	70.0	55.0	85.0	<0.001	46.66%	Equal to telehealthcare
Nguyen, 2013[31] (b)	THC1 vs C	12 months	Duration of endurance exercise (min/week)	60.0	46.0	74.0	<0.001	53.34%	
Overall				**64.7**	**54.4**	**74.9**	**<0.001**	**100%**	



Heterogenity: Q = 0.91, df (Q) = 1; I^2 = 0% (p = 0.339), Eggers (NA)

Figure 2 Forest plot of the effect of telehealthcare on physical activity level. Abbreviations: C = comparator; CI = confidence interval; MD = mean difference; THC = telehealthcare.

Dyspnea

Dyspnea was reported in seven studies (Table 1) [28,29,31–35]. The Chronic Respiratory Questionnaire, Dyspnea subscale (CRQ-D) [28,31,33–35], Medical Research Council (MRC) Dyspnea scale [29], and Shortness of Breath Questionnaire (SOBQ) [32] were selected for the meta-analysis. No difference between telehealthcare and comparator was found for dyspnea (SMD, 0.088; 95% CI −0.056 to 0.233; $p = 0.232$) (Fig. 4). No evidence of publication bias was given by Egger's test ($p = 0.412$).

Telehealthcare interventions

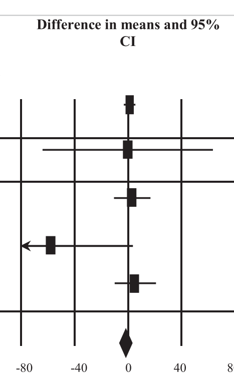
In a majority of the studies, the telehealthcare intervention consisted of regular phone calls with reinforcement, feedback and support [27–29,33–35]. As complement to the phone calls, education about self-management [27,29,33] and/or exercise training [27,28,33,34] were used. A website was used by patients to report physical activity level, pulmonary function and symptoms (dyspnea, sputum, signs of a cold), and to get education and feedback [31]. Reporting was also made via mobile phones with feedback through short text messages [30]. Both website and mobile phone interventions were combined with individualized exercise and self-care plans [30,31]. Live-education using telehealthcare was carried out through text chats [31] or video-calls [32]. The duration of the interventions ranged from four weeks to 18 months.

The telehealthcare interventions were compared with ordinary care (optimized medication and ordinary health care contacts) [27,29,35], exercise training [28,30,34], or education [31–33]. Some comparators also received telehealthcare, although not as the major part of the intervention [34], or without feedback [28,30,31]. Some groups had received exercise training [28,35] and/or self-management education [34,35] before baseline assessment.

Discussion

This systematic review of nine studies, is the first to investigate the effect of telehealthcare on physical activity level, physical capacity and dyspnea. The results from the meta-analysis may imply that telehealthcare have an effect on physical activity, however this is the results from one study only and further studies are needed. Despite the weak support, this is of great importance since physical activity level is the strongest predictor for mortality in this group of patients [3]. Telehealthcare did not affect physical capacity and dyspnea. The results should be interpreted with caution due to heterogeneity even though. However, several strategies have been used to decrease the impact of heterogeneity. Both duration of telehealthcare and

Study	Comparison	Duration	Outcome	MD (m)	Lower limit	Upper limit	P-value	Weight	Comparator
Bourbeau, 2003[27]	THC vs C	12 months	6MWT	-3.0	-8.1	2.1	0.248	66.16%	Ordinary care
Nield, 2012[32]	THC vs C	4 weeks	6MWT	0.1	-62.8	63.0	0.997	1.15%	Less than telehealthcare
Carrieri-Kohlman, 1996[28]	THC vs C	8 weeks	6MWT	4.0	-11.2	19.1	0.609	16.79%	Equal to telehealthcare
Nguyen 2009[30]	THC vs C	6 months	6MWT	-57.4	-118.0	3.2	0.064	1.24%	
Maltais, 2008[35]	THC vs C	12 months	6MWT	5.0	-11.4	21.4	0.551	14.67%	
Overall				**-1.3**	**-8.1**	**5.5**	**0.708**	**100%**	

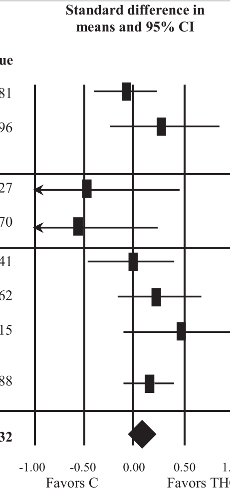


Heterogenity: Q = 4.65, df (Q) = 4; I^2 = 14% (p = 0.325), Eggers = -0.21 (p = 0.813)

Figure 3 Forest plot of the effect of telehealthcare on physical capacity. Abbreviations: 6MWT = 6-min walk test; C = comparator; CI = confidence interval; MD = mean difference; THC = telehealthcare.

Study	Comparison	Duration	Outcome	SMD	Lower limit	Upper limit	P-value	Weight	Comparator
Waterhouse, 2010[36]	THC vs C	18 months	CRQ-D	-0.088	-0.401	0.225	0.581	21.45%	Ordinary care
Garcia-Aymerich, 2007[29]	THC vs C	12 months	MRC	0.276	-0.242	0.793	0.296	7.84%	Ordinary care
Nield, 2012[32]	THC vs C	4 weeks	SOBQ	-0.458	-1.373	0.458	0.327	2.50%	Less than telehealthcare
Oh, 2003[34]	THC vs C	8 weeks	CRQ-D	-0.578	-1.403	0.247	0.170	3.08%	Less than telehealthcare
Nguyen, 2013[31] (a)	THC2 vs C	12 months	CRQ-D	-0.016	-0.440	0.408	0.941	11.67%	Equal to telehealthcare
Nguyen, 2013[31] (b)	THC1 vs C	12 months	CRQ-D	0.241	-0.180	0.662	0.262	11.82%	Equal to telehealthcare
Carrieri-Kohlman, 1996[28]	THC vs C	8 weeks	CRQ-D	0.436	-0.107	0.979	0.115	7.11%	Equal to telehealthcare
Maltais, 2008[35]	THC vs C	12 months	CRQ-D	0.165	-0.081	0.412	0.188	34.57%	Equal to telehealthcare
Overall				**0.088**	**-0.056**	**0.233**	**0.232**	**100%**	

Statistics for each study



Heterogenity: Q = 8.3, df (Q) = 7; I^2 = 16% (p = 0.308), Eggers = -0.91 (p = 0.412)

Figure 4 Forest plot of the effect of telehealthcare on dyspnea. Abbreviations: C = comparator; CI = confidence interval; CRQ-D = chronic respiratory questionnaire, dyspnea subscale; MRC = Medical Research Council; SMD = standardized mean difference; SOBQ = Shortness of breath questionnaire; THC = telehealthcare.

magnitude of comparator intervention were presented in Figs. 2—4, although no visual pattern of their influence on the results could be seen.

The comparators did often have similar interventions to the telehealthcare groups, but without the contact through phone or internet. This may, of course, contribute to the small differences between groups in the meta-analysis, since several studies found within-group changes for the different outcomes. In addition, Goetzsche et al. [36] note that when comparing active treatments, even a difference of 0.1 can be important, since there is relatively small difference between the treatments. This indicates that telehealthcare can, in fact, be helpful in making PR more available, although this requires further studies.

The outcome measures used in the included studies can be discussed. The 6MWT was the most commonly used outcome for physical capacity. However, endurance shuttle walking test (ESWT) has shown better responsiveness than 6MWT regarding physical capacity [37], which might explain lack of effect. Further, only three studies had measured physical activity level, one with an objective measure and two with questionnaires (minutes/week and yes/no, respectively). Only one of these studies, with two intervention groups, could be included in the final meta-analysis, which is a major limitation and of course affect the possibility to draw strong conclusions. Questionnaires are the easiest way to measure physical activity level, although both the validity and reliability of this method are weak. Objective measures, like motion sensors, give a more accurate information [38,39] and are therefore recommended. These sensors should preferably measure steps per day or time in light activity, during four weekdays [40]. This meta-analysis showed effect on level of physical activity. In systematic reviews evaluating telehealthcare for other chronic diseases, the effect on physical activity level varies [41—44]. Increasing physical activity level requires a change of behavior and there might be a need for more support for the participants to cope with this. Moreover, for dyspnea different scales were used, although this was dealt within the meta-analysis as the effect measures were recalculated to SMD.

Other limitations should also be taken into account when interpreting the results. Many of the included studies were judged to have a high risk of bias for several domains, which also reduce the possibility to draw any robust conclusions. We chose only to include RCTs to decrease the risk of bias. Even though authors are strongly recommended to register clinical trials [45,46], most studies lacked this information. Therefore, we had no opportunity to judge if all pre-specified outcomes were reported. The most common cause of high risk of bias was lack of blinding of participants and personnel, since it is hardly possible to blind participants, especially when comparing to usual care. The personnel giving the treatment cannot be blinded at all in this kind of interventions. This is a lack in Cochrane risk of bias tool [26], since it is almost impossible to have double-blinded procedures when performing clinical studies with exercise or behavioral changing interventions.

In many studies, the telehealthcare intervention was combined with different variations of education and exercise training. Therefore, it is not possible to determine what results that were caused by telehealthcare and what results that was caused by education and exercise training. To be able to conclude that with certainty more studies with telehealthcare as the only intervention is needed. Furthermore, very few studies used the internet to deliver telehealthcare. Since the use of the internet is constantly increasing, this may open new paths to reach out with rehabilitation to patients. Therefore, there is a need for more studies evaluating telehealthcare, including studies using the internet as the main intervention, in order to determine whether telehealthcare can be effective in increasing physical activity level and physical capacity and decreasing dyspnea. The studies should be carefully designed to minimize the risk of bias. To be able to generalize the results for the whole COPD population and to see differences between stages of disease severity, telehealthcare must be evaluated for patients across the whole span of disease severity. The studies included in this systematic review only included patients with moderate to severe COPD. Patients living in remote might be of benefit of telehealthcare, as well as patients in need to maintain positive effects after PR, although the effect for these groups of patients has not been evaluated separately. It is important that all patients get equal treatment, which even more highlights the importance of research in the area of telehealthcare [6].

Conclusion

This is the first systematic review to investigate the effect of telehealthcare on physical activity level, physical capacity and dyspnea. Compared to comparators the use of telehealthcare may lead to increased physical activity level. No effect on physical capacity and dyspnea was found. The results should be considered with caution given the heterogeneity among the studies. Telehealthcare in the included studies consisted of information, feedback, and reporting by phone calls, internet or mobile phone in combination with education and exercise. This is an important area of research and further studies of the effect of telehealthcare for patients with COPD are required.

Author contributions

Mrs Lundell: contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting and revision of the manuscript.

Dr Holmner: contributed to the conception and design of the study, acquisition of data, interpretation of data and revision of the manuscript.

Dr Rehn: contributed to the conception and design of the study, acquisition of data, interpretation of data and revision of the manuscript.

Dr Nyberg: contributed to the design of the study, analysis and interpretation of data and revision of the manuscript.

Dr Wadell: contributed to the conception and design of the study, acquisition of data, analysis and interpretation of data and revision of the manuscript. She is the guarantor of the data the analysis and the content of this manuscript.

All authors have approved the final version of the manuscript.

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Summary conflict of interest statements

None of the specified authors have any conflict of interest to report.

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Appendix A—D. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.rmed.2014.10.008.

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