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ORIGINAL RESEARCH

Real-Time Telehealth for COPD Self-Management Using Skype™

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Abstract

The utility of real-time interactive voice and video telehealth for teaching pursed-lips breathing (PLB) in chronic obstructive pulmonary disease (COPD) is unknown. This was a pilot study to determine its feasibility and efficacy on the key variables of social support and dyspnea. A randomized control study design with repeated measures (baseline, 4 and 12 weeks) was used. All participants in the control and intervention groups received PLB instruction at baseline, but only the intervention group received one weekly PLB reinforcement session for 4 weeks via home computer and Skype™ software. Outcome measures were Medical Outcomes Study Social Support Survey and dyspnea assessment (visual analogue scales for intensity and distress, modified Borg after six-minute walk distance, and Shortness of Breath Questionnaire for activity-associated dyspnea). A total of 22 participants with COPD (mean FEV_1 % predicted = 56) were randomized; 16 (9 telehealth, 7 control) completed the protocol. Intent-to-treat analysis at week 4, but not week 12, demonstrated significantly improved total social support ($P = 0.02$) and emotional/informational subscale ($P = 0.03$) scores. Dyspnea intensity decreased ($P = 0.08$) for the intervention group with a minimal clinical important difference of 10.4 units. Analysis of only participants who completed the protocol demonstrated a significant decrease in dyspnea intensity ($P = < 0.01$) for the intervention group at both week 4 and 12. Real-time telehealth is a feasible, innovative approach for PLB instruction in the home with outcomes of improved social support and decreased dyspnea.

Keywords: Social support, Dyspnea, Breathing strategy, Telecommunication.

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Introduction

Healthcare access for patients with limited mobility and complex co-morbidities can be daunting. A rapidly expanding option for those with chronic diseases is telehealth (1–4), the remote delivery of Internet-supported health delivery activities (5). The growth of telehealth parallels the development of technology from closed circuit television link-ups, personal computers and broadband Internet to smartphones in the 21st century. State-of-the art computers coupled with innovative software significantly impacts health delivery. At the societal level, telehealth can positively impact healthcare utilization (6,7) and improve healthcare access and efficiency. At the individual level, telehealth activities such as symptom monitoring, patient education and self-management training can promote positive health outcomes (8,9). Symptoms may be reduced and subjective well-being may be improved. It

offers convenience to patients in terms of time and effort and lowers barriers to health promotion activities often present in traditional forms of healthcare.

Teaching dyspnea self-management to those with a chronic disease such as chronic obstructive pulmonary disease (COPD) is an ideal application of telehealth. Chronic dyspnea is the most frequently reported symptom of COPD and its negative impact on physical activities (10) and health-related quality of life is well-known (11). Telehealth may be a desirable option for COPD management, especially for home-bound elderly, as regular interaction with a health care provider may contribute to increased perceived social support. Elderly adults, due to loss of loved ones or limitations related to chronic conditions, may experience social disconnectedness and social isolation with increased risk for morbidity (12,13), and mortality (14). Research on the positive impact of social support on health outcomes suggests that increased perception of the availability of social support may improve health outcomes (15,16).

A feasibility study was conducted to determine if one component of a dyspnea self-management program, pursed-lips breathing (PLB), could be delivered to the home via real-time interactive voice and video telehealth using Skype™ software. The sample was adults with moderate to severe COPD. The aims were to study if real-time interactive voice and video telehealth: 1) is a feasible option for teaching PLB and, 2) significantly increases perceived social support and decreases dyspnea compared to those who do not receive telehealth PLB education sessions. PLB was selected since it is a consensus recommendation by several medical professional societies (17,18) and is a relatively simple skill. Purposeful application is often unrecognized by patients and consequently underutilized. Although it may be self-taught (19), PLB requires instruction and feedback for optimal usage.

Methods

A prospective, randomized control design with repeated measures was used to compare a one-time PLB education session to a PLB education session plus a 4 week telehealth PLB program. Study measures were obtained at baseline, 4 weeks, and 12 weeks. Certification of Institutional Review Board (IRB) Approval by IRB C at Veterans Affairs (VA) Greater Los Angeles Healthcare System, Research and Development Service, was obtained.

Study participants

Participants were recruited from the outpatient pulmonary clinic at the West Los Angeles VA Healthcare Center. A sample size of 15 participants per group for a total of 30 was considered representative of the targeted population with COPD based on results from a prior study (20) on the efficacy of PLB at the same institution. Because of the feasibility nature of the study, power calculations were not done (21).

Inclusion criteria were adults greater than 45 years of age with a COPD diagnosis, forced expiratory volume in 1 second/forced vital capacity percent (FEV_1/FVC %) less than 70, FEV_1 % predicted less than 80 with no reversibility after inhaled bronchodilator, and a shortness of breath score of at least 3 when walking assessed with the modified Medical Research Council (MRC) chronic dyspnea questionnaire (22). Exclusion criteria included hospital admission within the past four weeks and change in bronchodilator therapy within the past 2 weeks. Prior computer use and/or Internet access were not used to determine eligibility or exclusion.

Study protocol

Baseline

At baseline, participants provided consent for inclusion in the study, confirmed the presence of exertional dyspnea, and completed study questionnaires. All participants in the control and intervention groups received a 10-minute PLB education session from a healthcare professional. It consisted of: 1) review of participant's FEV_1 and residual volume values; 2) watching a 2- minute video clip on PLB with a return demonstration; and 3) review of the educational packet. The packet was provided to both groups and contained COPD health education material, a log book for recording daily practice times and duration, and written instructions for PLB technique and practice schedule. Frequent short practice sessions for a total of 10 minutes/day the first week, 15 minutes/day the second week, 20 minutes/day the third week, and 25 minutes/day the fourth week were specified. Suggested practice times for the first week were early morning, late morning, afternoon, and evening. Home computer instructions were added for the intervention group. Participants were then randomized into the control or intervention group by a staff member not associated with the study. After this point, the control group did not receive further PLB instruction in person or via telehealth.

Telehealth sessions

One weekly telehealth session of 15–30 min for 4 weeks was prescheduled for the intervention group. The health educator (the same health professional who provided the baseline PLB educational session) made a telephone call just prior to the session to remind the participant and then initiated the telehealth session via Skype™. The telephone call ended after the participant had opened the laptop, checked headphone connections, activated the computer, and the Skype™ image appeared. The participant answered the request to initiate the session by using the trackpad. A cue card with "I can't hear you" was used by either the participant or health educator if there was visual contact but no audio. The health educator then called the participant to resolve the issue. The sessions focused on PLB for dyspnea relief with feedback on technique and instruction on the application of PLB with activities of daily living such as walking. Practice log books were reviewed at each session.

Technical information

A laptop computer (MacBook®, 13 inch, 2.0 GHz Intel Core 2 Duo, webcam, Apple Inc, Cupertino, California), headphone (Plantronics Audio™ 625 USB) and pulse oximeter (Nonin Onyx® II 9550, Plymouth, MN) were provided for one month. Skype™ (version 2.8.0.772.dmg, Skype Technologies S.A., Luxembourg), a free, web-based software program, enabled synchronous voice and video communication via the Internet.

The computer was set up with a fixed mode for operation with Skype™ starting at computer activation. Color coding for four keyboard function keys, computer activation and shut-off was done for ease of use. Privacy and security were maintained by blocking Internet access for the participant and not storing any personal health data on the computer used by the health educator. Demonstration of the basic computer functions was done at baseline and again by the research assistant when the computer was set up in the home. Internet service was established with the provider in the geographical area of each participant in the intervention group. Participants were reimbursed for costs associated with Internet set-up and one month service. If Internet speed was not adequate, reassignment to the control group was offered.

Social support

The Medical Outcomes Study (MOS) Social Support Survey

The MOS Social Support Survey, developed for chronic health conditions, was used to measure social support (23). The tool is a 19 item, brief, self-administered survey with 1 (none of the time) through 5 (all of the time) as possible responses. It has a functional social support total score and 5 subscales named emotional/informational support (8 items), tangible social support (4 items), affectionate social support (3 items), positive social support (3 items) and one item about socialization for distraction. Examples of the emotional/informational support items are: "someone to give you information to help you understand a situation," "someone to confide in or talk about yourself or your problems," and "someone whose advice you really want." A higher score indicates more support.

Dyspnea

The multi-dimensional nature of dyspnea requires different measures to capture its complexity (24). Dyspnea intensity reflects the perceived effort or work of breathing and dyspnea distress reflects the affective component of anxiety associated with dyspnea. All tools have established reliability and validity.

Visual Analogue Scale (VAS)

Dyspnea intensity and dyspnea distress were measured with the VAS, a 100-mm horizontal line with verbal anchors at each end. For dyspnea intensity, the subject marked the line in response to the question, "During the last 24 hours, how easy or how hard was it to get your breath?" A second VAS scale for dyspnea distress was marked in response to the question, "During the last 24 hours, how bothered were you by your shortness of breath?" The minimal clinically important difference (MCID) for VAS scores ranges between 10–20 units (25).

Borg category-ratio scale

The modified Borg category-ratio scale (26) was originally used for rating perceived effort during exercise. The scale has a 0–10 range and a MCID of 1 unit (25). The scale was administered at the beginning and end of the 6-minute walk distance (6MWD) (27).

Shortness of Breath Questionnaire (SOBQ)

The University of California, San Diego SOBQ (28) is a 24-item tool for measuring self-reported dyspnea severity with activity during the past week. The tool uses a 6-point scale with 0 = "not at all" and 5 = "maximally or unable to do because of breathlessness." Scores range from 0 to 120 with the lower number associated with less severe dyspnea. The MCID is 5 units (25).

Statistical analysis

Block randomized assignment with block sizes of 4 was used to guard against imbalance across groups. Assessment of baseline characteristics between groups was done with analysis of variance (ANOVA) and chi-square to assess group equivalency. An intent-to-treat analysis with examination of patterns over time for each outcome measure was done with a mixed-effects model and linear contrasts. The mixed-effects model adjusts for correlated errors due to repeated measures and maximizes analysis sample size by including all data points available for baseline, 4 weeks, and 12 weeks, even if participants' repeated measures are not complete. For participants who completed the protocol, analysis of covariance (ANCOVA) using a univariate general linear model was used to test for changes from baseline. All statistical tests used a Type 1 error rate of 5%. Data were analyzed with Statistical Package for the Social Sciences (SPSS), version 16.0, Chicago, Illinois and SAS®, version 9.2, Raleigh, North Carolina.

Results

Study participants

Over a 1-year recruitment period, 28 participants provided informed consent to participate and be screened for inclusion and exclusion criteria (see Figure 1). The final sample consisted of 22 participants with 11 randomized to the intervention group and 11 randomized to the control group. Of the 22 participants, 17 had moderate COPD and 5 had severe COPD based on post-bronchodilator FEV_1 % predicted. Six participants ceased participation before the end of the study. One participant withdrew consent, one had a weak broadband signal, two had pulmonary exacerbations, one was lost to follow-up, and

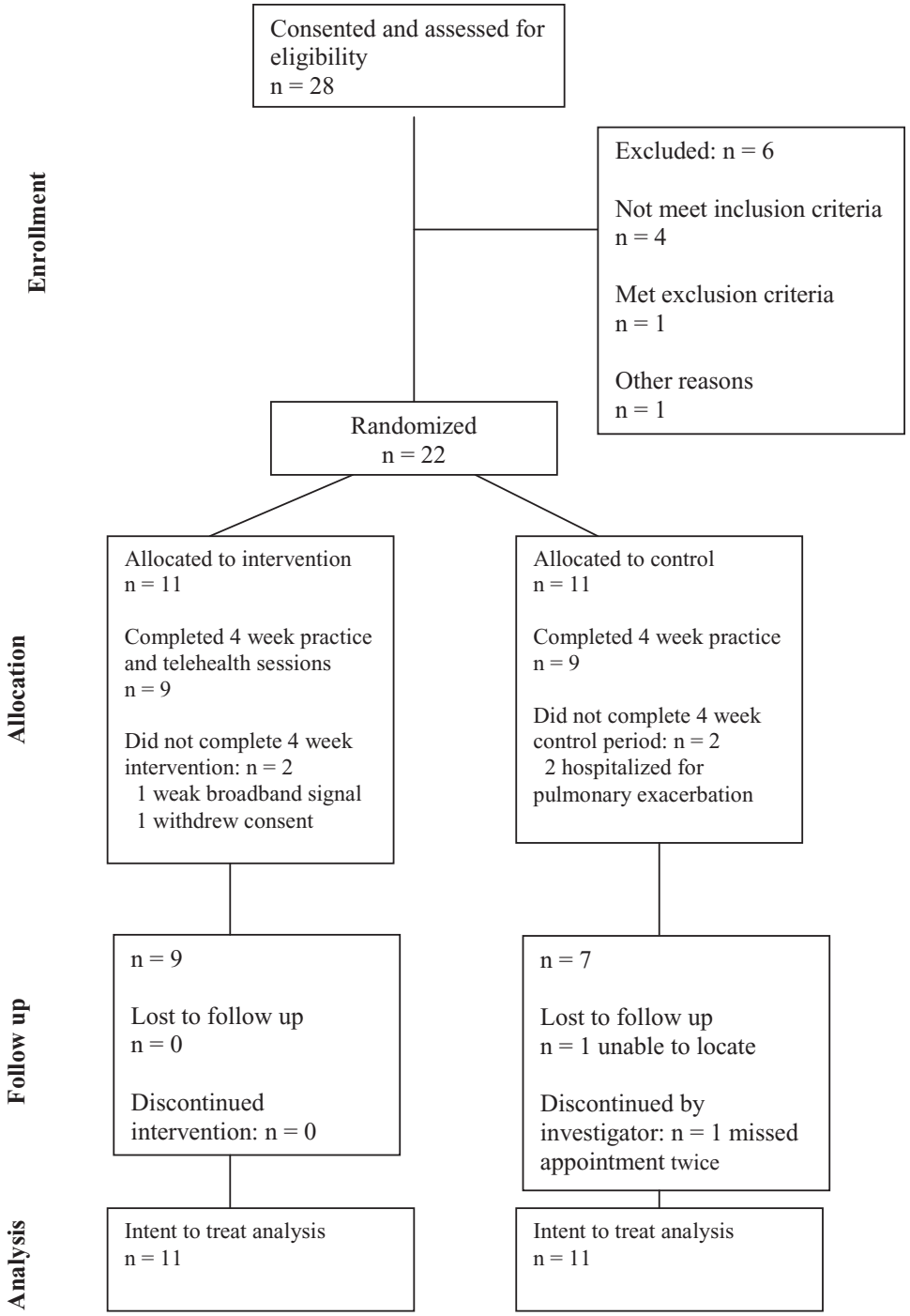


Figure 1. Flow of participants.

one was discontinued by the investigator due to missed appointments. There were no significant demographic and clinical differences between groups.

Baseline demographic and clinical characteristics of the two groups are shown in Table 1. Group equivalency was established for all physiologic variables at baseline and subsequent time points. All participants in the intervention group used the log books to record their practice times and duration. In contrast, 64% of the participants in the control group used the log books to record practice times. The protocol of short, frequent practice times with increased total daily practice time by 5-min intervals each week to a maximum of 25 min total per day by the end of week 4 was recorded by both groups. Proper PLB technique during the 4 weeks of practice could only be confirmed for the intervention group via the telehealth sessions.

Telehealth delivery

All participants were reached at the prescheduled times. However, delivery of sessions was not possible for one participant due to a weak broadband signal. Participant

Table 1. Demographic and clinical characteristics of two COPD groups at baseline.

	Group	
	Intervention	Control
Subjects, n	11	11
Sex, male/female	11/0	11/0
Race		
White	8	6
Black	3	4
Asian	0	1
Age, years	64±8	65±5
Body mass index	31±9	32±7
FEV_1, % predicted	55±16	56±12
FEV_1/FVC, %	53±10	56±8
RV, % predicted	177±55	195±27
DLCO, % predicted	59±18	66±15
PaO_2, mm Hg	72±10	66±6
Smoking status		
Current	5	6
Past	10	11
Co-morbid illnesses		
Arthritis	5	5
Hypertension	5	7
Coronary heart disease	3	2
Diabetes	3	6
Depression	5	6
PTSD	3	3
History alcohol/drug abuse	5	4
Co-morbid illnesses		
1	2	0
2	3	1
3 or more	6	10
Education		
<12 years	0	0
12 years	2	2
>12 years	9	9
Income		
< $10,000	3	2
$10,000 - $19,999/yr	3	4
$20,000 - $39,999/yr	4	4
>$40,000/yr	1	1
Lives alone	7	5
Computer		
Used in past	9	10
In home	6	8

Values are mean±standard deviation. COPD = chronic obstructive pulmonary disease, n = number, FEV_1 = forced expiratory volume for 1 second, FVC = forced vital capacity, RV = residual volume, DLCO = diffusing capacity of lung, carbon monoxide, P_aO_2 = partial pressure, arterial oxygen, PTSD = post traumatic stress disorder.

experience was consistently positive based on comments offered at study end. One participant stated that real-time telehealth was "A very good way to teach/learn. By doing this study, I decided to quit smoking to try and help my breathing." Another stated "This was a good program for me; it really opened my eyes to COPD". A third participant commented "It was great and a time-saver and just like seeing the doctor in person."

Measures

There were significant differences between groups at week 4 for the total score of the MOS Social Support Survey, t(29) = 2.40, P = 0.02, and the subscale emotional/informational support, t(29) = 2.25, P = 0.03. No differences were present for all other subscales. Cronbach's alpha reliability coefficient for all subscales was 0.862 (see Table 2).

Dyspnea intensity scores, measured by the VAS, decreased at week 4 by 10.4 units for the intervention group while dyspnea intensity increased for the control group at week 4 and 12. The changes did not reach statistical significance at week 4 (P = 0.08) with the intent to treat analysis, but group differences for participants who completed the protocol was significant at week 4 (df = 16, F = 9.18, P = 0.003) and week 12 (df = 16, F = 13.96, P = 0.001); see Table 3.

Change scores from baseline for dyspnea on exertion, measured with the modified Borg scale at the end of the 6MWD, decreased for both groups with no significant differences between groups at week 4 and 12. The 6MWD increased at each measurement point with no differences between groups. Dyspnea distress, measured by the VAS, decreased for both groups over time with no difference between groups. Dyspnea severity with activities measured by the SOBQ was reduced over both measurement points with no differences between groups.

Discussion

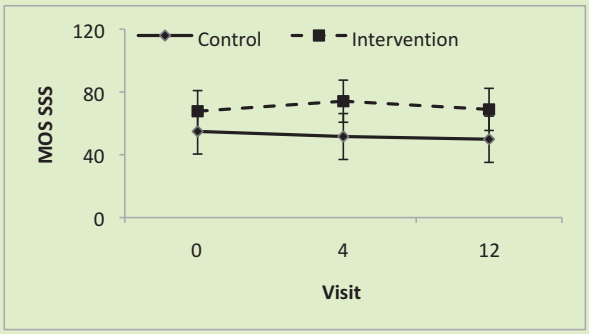
Providing healthcare for patients with chronic health conditions can be challenging. Patient load, time limitations, and costs can further complicate efficient healthcare delivery. Synchronous telehealth technology has the potential to eliminate many of these barriers, but demonstration of its efficacy is needed.

The most important outcome of this pilot project was the successful implementation of real-time interactive voice and video instructional sessions for COPD participants in their homes. Lack of computer access or prior computer experience did not impact the conduct of the study due to the computer's preconfigured start-up and operation. Using the same computer for the health educator and participant minimized technical issues.

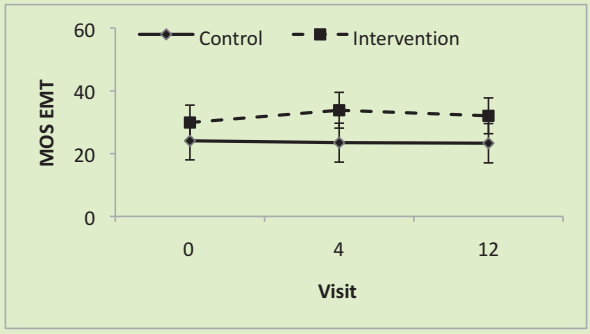
The intent-to-treat analysis identified a statistically significant increase in perception of social support for the intervention group and decrease in the control group. This was an unexpected finding for two reasons. Only 22 participants were randomized for this feasibility study rather than the targeted sample size of 30 and there are mixed reports about Internet use and social support. Research findings support both a positive impact of Internet use on social support and no impact (15,29,30). Two dyspnea self-management programs for COPD, using either weekly text chat sessions supplemented by bulletin board and e-mail (31) or web-based education modules supplemented by real-time chat sessions and a personal digital assistant (PDA) (32) reported no increase in social support. Our Internet intervention may explain these differences. Synchronous or real time voice and

Table 2. Patterns of change for social support.

a. Measure	COPD Group	Visit Week	Mean	SE	dF	95%	LCL	UCL	*P*
MOS Social	Control	0	54.9	7.0	29	14.4	40.5	69.3	
Support Score	Control	4	51.6	7.2	29	14.6	37.0	66.3	.02
	Control	12	49.9	7.2	29	14.7	35.2	64.6	.12
	Intervention	0	67.8	6.4	29	13.2	54.6	80.9	
	Intervention	4	74.1	6.6	29	13.4	60.7	87.6	
	Intervention	12	68.9	6.6	29	13.4	55.5	82.3	



b. Measure	COPD Group	Visit Week	Mean	SE	dF	95%	LCL	UCL	*P*
MOS Emotional	Control	0	24.1	3.0	29	6.1	18.0	30.2	
Score	Control	4	23.5	3.0	29	6.2	17.3	29.7	.02
	Control	12	23.3	3.1	29	6.3	17.1	29.6	.14
	Intervention	0	29.9	2.7	29	5.5	24.4	35.5	
	Intervention	4	33.8	2.8	29	5.7	28.1	39.5	
	Intervention	12	32.1	2.8	29	5.7	26.4	37.7	



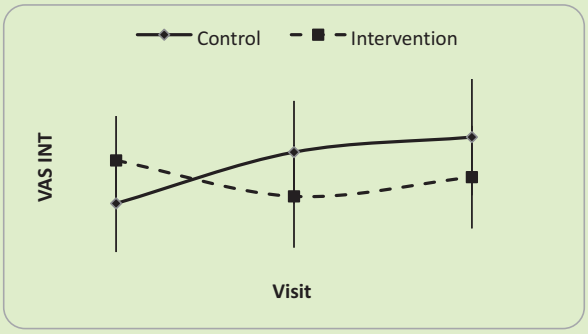
Medical Outcome Study Social Support Score (MOS SSS), EMT (Emotional), Chronic Obstructive Pulmonary Disease (COPD), standard error (SE), degrees of freedom (dF), lower confidence level (LCL), upper confidence level (UCL), *P* = probability.

video modalities rather than asynchronous store and forward modalities such as web-based modules or text-based chat rooms may be the preferred mode, especially if increased social support is the outcome of interest. Real-time interaction is likely to increase participants' sense of social support by providing regularly scheduled interaction with a live person interested in their well-being (33).

The randomized control trial design strengthened the clinical findings. For example, improved sense of social support could possibly occur with improved skill in PLB application to daily living activities so that increased social interaction and social support result. Or the improvement could be attributed to the weekly tele-health sessions alone. Because the MOS social support scores returned to baseline levels 4 weeks after the

Table 3. Pattern of change for dyspnea intensity.

Measure	COPD Group	Visit Week	Mean	SE	dF	95%	LCL	UCL	*P*
VAS	Control	0	29.4	6.9	30	14.1	15.3	43.5	
Intensity	Control	4	44.2	7.3	30	14.8	29.4	59.0	.08
	Control	12	48.6	8.2	30	16.8	31.8	65.4	.11
	Intervention	0	41.8	6.3	30	12.8	29.0	54.7	
	Intervention	4	31.4	7.3	30	14.8	16.6	46.3	
	Intervention	12	37.0	7.3	30	14.8	22.2	51.8	



Visual Analogue Scale Intensity (VAS INT), Chronic Obstructive Pulmonary Disease (COPD), Standard Error (SE), Degrees of Freedom (dF), lower confidence level (LCL), upper confidence level (UCL), *P* = probability.

telehealth sessions ended for the intervention group and continued to decline for the control group, it is likely the improved scores were due to the telehealth sessions and not improved PLB application.

Similarly, the MCID decrease in dyspnea intensity for the intervention group and increase for the control group suggests that weekly interactive sessions and feedback on PLB technique and application is likely to translate to a more consistent, smooth performance of PLB. Weekly review of their practice logs likely increased accountability and reinforced correct PLB technique. The decrease in dyspnea intensity was significantly different for those who completed the protocol, but due to patient drop-out, these differences did not reach statistical significance with the intent-to-treat analysis.

The structured 10- minute PLB education session alone had an impact on exertional dyspnea. The finding of persistent decrease in exertional dyspnea for both groups is similar to another randomized trial by Nield and colleagues (34) with the same PLB protocol. In that study, the PLB intervention group reported significantly less dyspnea over time, yet the attention-control group exceeded baseline values by the end of 12 weeks.

The advantages of self-management programs that use widely available, free software, enable one-on-one as well as group instruction, and provide immediate voice and video feedback with no requirement for patient travel are attractive. This kind of Internet self-management program is more likely to promote user engagement than traditional Internet programs that do not allow individually tailored content and do not provide feedback (35). Although a preconfigured computer was used to keep technical issues at a minimum, any type of personal computer or smartphone and sufficient broadband speed make implementation of a real-time telehealth program for symptom monitoring, patient education, or self-management training possible.

To our knowledge, this is the first report of a successfully implemented symptom self-management program using real-time voice and video technology and a randomized design in a provider to patient setting. Previous reports on the use of telehealth for COPD are limited to telemonitoring using either asynchronous store-and-forward modalities or the telephone (36–39). The only reports of synchronous voice and video telecommunication delivery in the home used videoconferencing equipment were to provide telepsychiatry for patients with a depressive disorder (40) or eating disorders (41).

Study limitations

The study intervention of telehealth instruction could not be blinded which may have introduced bias. Findings cannot be widely generalized since the sample consisted of male veterans from a large urban healthcare setting. Although the study was not powered to detect

an intervention effect for increased social support and the design did not allow the evaluation of the separate contributions of social support and PLB on dyspnea, significant differences were present. This calls for an adequately powered multi-site trial to compare costs and clinical outcomes of symptom self-management programs provided in a traditional face-to-face setting, asynchronous telehealth environment, and/or synchronous voice and video telehealth environment.

Conclusion

Weekly real-time interactive voice and video telecommunication between healthcare providers and the chronically ill is feasible. Low cost home telehealth systems using laptop computers and free software can improve healthcare access and deliver effective health education to enhance a self-management program. Telehealth participants with COPD and exertional dyspnea had a MCID decrease in dyspnea intensity with the added benefit of significantly increased perception of social support. Synchronous telehealth has the potential to revolutionize healthcare delivery.

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Declaration of Interests

Margaret Nield has no conflict of interest to disclose. Guy W. Soo Hoo is a member of the board of Breathe California of Los Angeles County. The funding sources (Breathe California of Los Angeles County and in part by National Institutes of Health [Grant P20 NR010671-01]) had no role in the design or conduct of the study, collection, management, analysis or interpretation of the data or preparation, review or approval of the manuscript. The authors are responsible for the content and the writing of this paper.

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