The effect of tele-rehabilitation on improving physical activity in patients with chronic obstructive pulmonary disease: A systematic review of randomized controlled clinical trials

Seyedeh Fatemeh Mousavi Baigi1*, Masoumeh Sarbaz2*, Kowsar Ghadari Pouri3, Nazanin Nouri3*, Khalil Kimiafar4

1MSc Student of Health Information Technology, Student Research Committee, Department of Medical Records and Health Information Technology, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran
2Associate Professor, Department of Medical Records and Health Information Technology, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran
3MSc Student of Health Information Technology, Department of Health Information Technology, Varastegan Institute for Medical Sciences, Mashhad, Iran
4Associate Professor, Department of Medical Records and Health Information Technology, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran

Introduction: Physical activity is a promising strategy to maintain the benefits gained after completing conventional pulmonary rehabilitation in people with chronic obstructive pulmonary disease (COPD). Therefore, the purpose of this study is a systematic review of randomized clinical trial and randomized controlled trials to investigate the effect of tele-rehabilitation on improving the physical activity of patients with COPD.

Material and Methods: A systematic review was conducted in randomized controlled clinical trial studies without time limit by searching for keywords in the title, abstract and study keywords in the valid scientific databases Embase, Web of Science, Scopus, PubMed on October 20, 2021. The quality of the studies was assessed using the Joanna Briggs Institute (JBI) checklist; Studies with a score above 7 were analyzed. This study was conducted according to the Preferred reporting Items for systematic reviews and meta-analysis (PRISMA).

Results: A total of 83 articles were identified. After screening the full text of the articles, 10 studies met the inclusion criteria. Studies were classified into two categories: randomized trial (60%) and randomized clinical trial (40%). The technologies used included video conferencing, cloud-based platform, mobile application and telephone calls. In 60% of the studies, tele-rehabilitation interventions had similar improvements in both control (face-to-face) and intervention (tele-technology) groups. However, in the rest, the intervention group reported a significant improvement compared to the control group.

Conclusion: The results of the present systematic review showed that although in most studies tele-rehabilitation interventions have the same results as traditional interventions, a well-designed tele-rehabilitation program to improve the physical activity of patients with COPD can supplement or replace the program. It is a traditional rehabilitation and improves the patient’s health.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is a chronic inflammatory disease of the lungs that blocks airflow from the lungs [1]. People with the disease face problems such as intolerance to exercise, shortness of breath, and ultimately a decline in
quality of life, which progresses over time [2]. In addition, people with COPD are at increased risk for heart disease, lung cancer, and other types. Conditions are. Pulmonary rehabilitation is a comprehensive and effective intervention in the complete evaluation of the patient, followed by appropriate treatment for the patient; these interventions include exercise, training and lifestyle changes to improve physical condition, promote long-term adherence to health-promoting behaviors [3]. Lack of adherence to rehabilitation programs is one of the possible reasons for non-stabilization of treatment and recurrence of the disease in these people [4]. Direct and indirect costs, including excessive consumption of resources, medical and pharmaceutical services, as well as the demand for support and social assistance caused by this disease have made it one of the major complications in public health [5, 6]. Therefore, ensuring that patients with COPD receive rehabilitation programs to properly manage their disease has become a major challenge [7]. More recently, the American Chest Association (ATS) and the European Respiratory Association (ERS) have recommended efforts to increase access to treatment programs for more patients and to explore alternative approaches to communicating with patients, such as tele-rehabilitation [8]. Proponents of tele-rehabilitation and physiotherapy see the use of communication and information technologies as a way to increase access and increase continuity of care [9, 10]. Therefore, the purpose of this study was a systematic review of randomized controlled trial and randomized controlled trials to investigate the effect of tele-rehabilitation on improving the physical activity of patients with COPD.

MATERIAL AND METHODS

Study design
This systematic review is based on PRISMA 2020 guidelines [11, 12]; to report the evidence from the input studies to this systematic review. The texts were searched on October 20, 2021 in the PubMed, Embase, Scopus and Web of Science databases. The keywords and phrases MeSH and Emtree in the following two categories were used to search the databases:
1. ("Physical Therapy Modalities", "Exercise Therapy", "Exercise Therapy", "physiotherapy", "exercise")
2. ("Telemedicine", "Telerehabilitation", "telehealth", "Mobile Health", "eHealth", "mHealth").

This review was limited to randomized and controlled trials so that we could evaluate the studies with the highest quality of evidence. The filter was also applied to the study population (patients with COPD) while reviewing the abstract and full text of the articles so that we do not miss other articles related to tele-rehabilitation. All articles were extracted from database searches and duplicate articles were removed from this review. Titles and abstracts were screened independently based on eligibility criteria. Articles that did not meet the inclusion criteria were excluded from this review. Complete texts were then retrieved and screened by two separate researchers based on eligibility criteria. Disagreements between researchers were resolved through discussion. Eligibility criteria

Studies which met all the inclusion criteria were included in the review:
1) Randomized clinical or controlled trial studies that used tele-rehabilitation or physiotherapy techniques to improve physical function and physical activity in patients with COPD;
2) The full text of the articles was available in English.

On the other hand, exclusion criteria were included:
1) Studies including books, review articles, letters, studies in the form of letters to the editor and conference summaries;
2) Lack of availability of the full text in English;
3) Lack of relevance of the title, abstract or full text of the articles for the purpose of reading.

Data extraction and synthesis
The same checklist was used to extract the data. The data elements in this checklist included the title of the publication, year of publication, country, number of participants, study method, duration of intervention, technology-based approach, intervention characteristics, study objectives and main findings of the study.

Quality control
In order to evaluate the quality of studies entering the study, the Joanna Briggs Institute (JBI) quality evaluation checklist for randomized controlled trials was used [13]. This checklist consisted of 13 questions to evaluate the quality of studies. If the answer to a question was yes, he would get a score of 1 and otherwise a score of zero. Therefore, the maximum quality evaluation score that each study could achieve was 13. Studies with a score less than 7 were excluded from this study.

RESULTS

Study selection
The process of identifying and selecting studies based on PRISMA diagrams is shown in Fig 1. A total of 2142 related documents were selected for review. After
reviewing the articles and eliminating duplicate studies (683 articles), 1459 articles were obtained and their screening was evaluated based on the titles and abstracts of the article. At the end of the review, 1997 articles that had nothing to do with the purpose of this study were deleted. Then, 83 articles were selected to review their full text, of which 73 articles were deleted and finally 10 main articles were included in the study.

The effect of tele-rehabilitation on improving physical activity in patients with COPD

The characteristics of all the studies included are reported in Table 1. Out of 10 included studies, 3 studies (30%) in the United States [17-19] and other studies in Denmark [14], Spain [5], Republic of Korea [15], Australia [2], Canada [16], South Korea [20] and England [21] is done. Studies were classified into two categories: randomized trial (5, 50%) [2, 5, 14, 15, 21] and randomized clinical trial (5, 50%) [16-20]. Input studies included 979 participants. The duration of intervention in each study varied from 8 weeks [17, 20] to 18 [15] (Table 2).

### Characteristics of the study

The results of evaluating the quality of articles in Table 1 show that there was no significant bias in the studies and all studies had the quality of inclusion in our study.

Table 1: Summary of article quality evaluation using JBI evaluation checklist

<table>
<thead>
<tr>
<th>Country/Reference</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denmark [14]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>10</td>
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<tr>
<td>Spain [5]</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Korea [15]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Australia [2]</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada [16]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>USA [17]</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USA [18]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>11</td>
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<td></td>
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<tr>
<td>USA [19]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>10</td>
<td></td>
<td></td>
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<tr>
<td>Korea [20]</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>England [21]</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

### Tele-rehabilitation approaches

Technologies used for tele-rehabilitation in studies including video conferencing (1, 10%) [14], cloud-based platform (1, 10%) [5], mobile-based application (1, 10%) [15] and telephone calls (6, 60%) [2, 16-21]. All of these interventions provide patient-to-patient communication with providers simultaneously. None of the studies used sophisticated technologies such as artificial intelligence or robots, and the goal of all studies was to monitor, adhere to, control, and train physical activity such as exercise, walking to improve physical activity, exercise tolerance, respiratory capacity, and ultimately improve patients' quality of life. He had COPD.

The effects of tele-rehabilitation on patients with COPD

In 60% of the tele-rehabilitation interventions studies had similar improvement in both control (face-to-face) and intervention (tele-saw technology) groups [2, 14, 16-18, 21]. However, in 4 studies (40%) of the studies, the intervention group reported a significant improvement compared to the control group. [5, 15, 19, 20] In all included studies, the control group underwent traditional (face-to-face) rehabilitation.
### Table 2: Summary of study characteristics

<table>
<thead>
<tr>
<th>Row</th>
<th>Country/Reference</th>
<th>Method</th>
<th>Intervention time</th>
<th>Purpose of the study</th>
<th>Number of participants</th>
<th>Type of intervention</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Denmark [14]</td>
<td>RCT</td>
<td>10 weeks</td>
<td>Evaluation of the difference between remote pulmonary rehabilitation and normal pulmonary rehabilitation in 6 minutes' walk (6 MWD) and its effect on respiratory symptoms, quality of life, physical activity and lower limb muscle function in patients with COPD.</td>
<td>134</td>
<td>Video conferencing</td>
<td>Analysis of the results showed no differences between groups for changes in 6MWD after intervention or at 22 weeks follow-up.</td>
</tr>
<tr>
<td>2</td>
<td>Spain [5]</td>
<td>RCT</td>
<td>12 months</td>
<td>Evaluating the effects of an integrated care program on a web-based platform on adherence to a 1-year maintenance program after pulmonary rehabilitation in COPD patients</td>
<td>44</td>
<td>HappyAir web-based platform</td>
<td>The improvement of adherence in the intervention group with HappyAir during 12 months was statistically different from the control group (p = 0.001).</td>
</tr>
<tr>
<td>3</td>
<td>Korea [15]</td>
<td>RCT</td>
<td>18 months</td>
<td>Design and evaluation of a comprehensive rehabilitation management platform to improve physical activity and quality of life in patients with COPD.</td>
<td>85</td>
<td>Android mobile based application + monitoring through the website</td>
<td>After 6 weeks, the scores of COPD evaluation test were significantly reduced in the intervention group with the application (P = 0.01) and signs of improvement were also seen in the monitoring group through the website. In addition, the user experience aspects of the programs were moderate to high in both intervention groups.</td>
</tr>
<tr>
<td>4</td>
<td>Australia [3]</td>
<td>RCT</td>
<td>6 months</td>
<td>Evaluation of the effects of home pulmonary rehabilitation in people with mild COPD.</td>
<td>58</td>
<td>Home visit + weekly calls</td>
<td>Both groups showed improvements in exercise capacity, symptoms, and health-related quality of life over time, however, there was no difference in 6MWD at the end of the intervention or 6 months. At 6 months of age, participants in home pulmonary rehabilitation were most likely to have clinically significant improvements in emotional function (P = 0.001).</td>
</tr>
<tr>
<td>5</td>
<td>Canada [16]</td>
<td>Multicenter RCT</td>
<td>12 months</td>
<td>Evaluate the continuous impact of self-management of patients with COPD compared to the use of hospital services</td>
<td>191</td>
<td>Electronic Remote Sensing: Weekly phone calls</td>
<td>Patients’ physical capacity did not show any change within or between groups during 12 months. But little improvement was reported in patients’ overall quality of life scores.</td>
</tr>
<tr>
<td>6</td>
<td>USA [17]</td>
<td>RCT</td>
<td>8 weeks</td>
<td>Evaluate whether exercise with a trainer is more effective than exercise alone in reducing shortness of breath and related anxiety and improving exercise performance, self-efficacy for walking, and shortness of breath with daily activities in COPD patients.</td>
<td>51</td>
<td>Weekly phone calls with reinforcement for walking and controlling shortness of breath for 8 weeks</td>
<td>Shortness of breath and anxiety significantly improved for both groups after ventilation intervention (p &lt; 0.05). However, there was no significant difference between the groups in any of the outcomes.</td>
</tr>
<tr>
<td>7</td>
<td>USA [18]</td>
<td>Pilot RCT</td>
<td>6 months</td>
<td>Feasibility and effectiveness of a six-month continuous mobile-based exercise intervention for patients with COPD after pulmonary rehabilitation.</td>
<td>17</td>
<td>Continuous mobile-based practice</td>
<td>There are no significant changes within the group in the level of physical activity.</td>
</tr>
<tr>
<td>8</td>
<td>USA [19]</td>
<td>RCT</td>
<td>12 months</td>
<td>Evaluation of the effectiveness of two 12-month self-management programs on Internet-based and face-to-face shortness of breath, compared with a public health education control.</td>
<td>125</td>
<td>Web-based self-management program</td>
<td>Improvement of exercise in arm endurance was seen in the intervention group compared to the control group (P = 0.04), exercise behavior, performance, and health-related quality of life were not different in the groups (P&gt; 0.05)</td>
</tr>
</tbody>
</table>
The effect of tele-rehabilitation on improving physical activity in patients COPD

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<table>
<thead>
<tr>
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<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Korea [20]</td>
<td>RCT</td>
<td>8 weeks</td>
<td>Evaluation of the effects of a home pulmonary rehabilitation program on lung function, shortness of breath, exercise tolerance and quality of life in patients with COPD</td>
<td>34</td>
<td>8-week pulmonary rehabilitation program at home</td>
<td>The experimental group showed a lower level of activity-induced dyspnea, more exercise tolerance, and improved health-related quality of life than the control group (p &lt; 0.05).</td>
</tr>
<tr>
<td>10</td>
<td>England [21]</td>
<td>RCT</td>
<td>18 months</td>
<td>Evaluating the effectiveness and cost-effectiveness of a remote pulmonary rehabilitation program by telephone versus traditional rehabilitation</td>
<td>240</td>
<td>Phone calls encouraging exercise</td>
<td>The pulmonary rehabilitation offered in a social setting has a similar effect as that produced in a more traditional hospital setting, both of which provide significant improvement in exercise capacity and quality of life acutely after long-term follow-up.</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The purpose of this systematic review was to investigate the effect of tele-rehabilitation on improving physical activity, physical function and quality of life in patients with COPD. The results of our systematic review showed that although in the majority of included studies, rehabilitation interventions and tele-physiotherapy have the same results as traditional interventions [2, 14, 16-18, 21]. However, tele-rehabilitation services reduced the hospital admission rate and referrals to physicians in the emergency department and acute care [16]. In addition, the results show that comprehensive pulmonary rehabilitation programs, including distance rehabilitation in improving patients’ physical activity, reduce COPD patients’ shortness of breath during exercise [17].

Mobile-based remedial rehabilitation programs have been reported as an active and cost-effective control intervention that can easily increase the provision of rehabilitation services from this platform [16, 18]. Also, in four cases of studies, better improvement was seen in the tele-rehabilitation group compared to traditional rehabilitation [5, 15, 19, 20]. Only two of the 10 inbound studies to our study used the app and website for tele-rehabilitation. However, in both studies, significant improvement was reported in the intervention group with tele-rehabilitation [5, 15].

In Kwon et al. study, the tele-rehabilitation approach was implemented using two mobile application platforms and web-based monitoring as a comprehensive platform for rehabilitation management to improve physical activity and quality of life in patients with COPD. The results of their study showed that both the website and application platforms have improved all the outcomes of the control group [15]. In addition, in the study by Jiménez et al., A web-based platform was developed to improve exercise tolerance and quality of life in patients with COPD, which showed that individuals in the intervention group with web-based platform significantly improved their fatigue range during exercise and walking. There are [5]. Oh’s study reported that a home-based pulmonary rehabilitation program with a nurse in which the intensity of the patient’s tail and tail muscle exercises was controlled based on their condition had significant benefits. He stated that a program in which the intensity of exercise is controlled by each patient may improve the sense of self-efficacy about the program and lead to continuous program execution [20].

In addition, with a web-based self-management program, participants sent instant information about their breathing symptoms and exercise using their tablet or smartphone, and were asked for a list if the patient reported not exercising. Choose from the reasons that keep them from exercising that day. Nurses then used this information to provide feedback and enhance individual participation to participants regarding the use of short-term management strategies and exercise progress through email or telephone call on a weekly basis. Also, as participants reported worsening of their symptoms, automatic email alerts were sent to nurses, which followed up according to the patient’s specific condition. Therefore, this program encouraged and better controlled patients and as a result, their self-efficacy in improving their condition [19].

However, the characteristics of health care providers and tele-care personnel along with the type of tele-rehabilitation platform may be important in achieving the desired result and care should be taken in hiring and training staff [21]. In 4 of the 6 studies that used the telephone call approach to follow-up, educate and monitor patients, more improvement in physical activity, exercise capacity and quality of life was reported in the intervention group than in the control group. In previous systematic review studies evaluating tele-health care for other chronic diseases, the effect on physical activity levels was different [22-24]. Increasing the level of physical activity requires behavior change and may require more support for
participants to cope.

However, in line with the results of this study, Lundell et al. conducted a systematic review to investigate the effects of distance care on the level of physical activity, physical capacity and shortness of breath in patients with COPD [25]. The results of their study showed that the use of distance health care may lead to improved levels of physical activity. Also, Johnson et al. in their systematic review concluded that patients in the intervention group with tele-rehabilitation had a similar improvement in physical performance compared to patients in the control group (face physiotherapy) [26].

One of the strengths of this systematic review was that it included only randomized controlled clinical trial studies, which reduced the study bias and provided credible evidence. Among the limitations of this study, the keywords searched may not be sufficient and complete to obtain further studies, and some prominent and relevant studies may not be included in this study. In addition, only peer-reviewed studies published in scientific journals and conference proceedings are included in this study; therefore, it does not cover articles published in the gray literature. Also, the included studies had very heterogeneous designs and used different methods to measure the results of the interventions; therefore, it was not possible to perform meta-analysis or study the effect of these studies as a group.

CONCLUSION

The results of our systematic review showed that although in the majority of studies interventional rehabilitation and physiotherapy interventions have the same results as traditional interventions. However, a well-designed tele-rehabilitation program to improve the physical activity of patients with COPD can complement or replace traditional rehabilitation programs and improve the patient’s health. In addition, given that other technologies, including applications and monitoring websites, have a better impact on telemedicine-based rehabilitation approaches, it seems that by using newer technologies with more communication facilities, rehabilitation is more likely to be effective and successful. The distance will be more.

AUTHOR’S CONTRIBUTION

All authors contributed to the literature review, design, data collection and analysis, drafting the manuscript, read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this study.

FINANCIAL DISCLOSURE

No financial interests related to the material of this manuscript have been declared.

REFERENCES


