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REVIEW PAPER

Effectiveness of Inspiratory Muscle Training among Chronic Obstructive Pulmonary Disease Patients: A Systematic Review

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Abstract

Inspiratory muscle training (IMT) has been shown to be effective for some types of illnesses or conditions, including respiratory problems, cardiac disorders, and neuromuscular disorders. Reduced exercise capacity and health-related quality of life, weakness of respiratory muscles, and complaints of dyspnea are all frequent among COPD patients. This study aimed to investigate whether the use of IMT can alter the consequences of COPD in patients and provide an updated understanding of the effects of IMT in COPD patients. The specific objectives of the study were to evaluate the effectiveness of IMT on respiratory muscle strength, exercise tolerance, dyspnea, and health-related quality of life in COPD patients. Included databases were the Physiotherapy Evidence Database (PEDro), Google Scholar, and PubMed. A preliminary selection of papers was produced using inclusion/exclusion criteria. Subsequently, a final selection was made based on the quality of the studies assessed using the PEDro scale. For the realization of this systematic review, seven studies were involved. According to the evidence gathered from the literature review, IMT therapy has been shown to improve respiratory muscle strength, exercise tolerance, perception of dyspnea, and health-related quality of life in COPD patients. It is necessary to conduct studies using high-quality, evidence-based data to draw more definitive conclusions about the effectiveness of IMT in COPD patients. Future research should examine whether these improvements are applicable to all COPD patient groups. Additionally, it should explore the long-term effectiveness of these therapeutic improvements and determine which IMT treatment protocol provides the most significant clinical benefits.

Keywords: *respiratory muscle strength, exercise tolerance, dyspnea perception, quality of life*

Introduction

Chronic Obstructive Pulmonary Disease (COPD) is a preventable and treatable condition characterized by airflow limitation. Although it primarily affects the lungs, it can also have serious systemic effects (Viegi et al., 2007).

It is increasingly recognized that many COPD patients have co-morbidities that significantly impact their survival and quality of life. Chronic and worsening dyspnea, coughing, and sputum production are common symptoms of COPD (Vogelmeier et al., 2017). The most significant symptom of COPD is shortness of breath. Patients are increasingly dependent on their accessory muscles to maintain breathing, particularly during physical activities (Calverley & Georgopoulos, 2006).

COPD results in reduced physical activity, which leads to deconditioning, mainly due to difficulty breathing. This results in a greater fear of exertion and a decreased interest in social and physical activities, which can trap the patient in a vicious cycle that worsens isolation and depression and lowers their quality of life (Corhay et al., 2014).

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Improvements in exercise capacity, a reduction in perceived dyspnea severity, an increase in health-related quality of life, and a decrease in hospitalizations and hospital stays are all advantages of pulmonary rehabilitation (PR) for COPD patients (Gloeckl et al., 2013). Patients with stable COPD may benefit from a PR program, as may those who have recently experienced an exacerbation. All individuals experiencing systemic effects from COPD are suitable candidates for PR. The four primary components of PR are education, nutritional assistance, psychological support, and exercise therapy (Corhay et al., 2014).

Respiratory muscle therapy (RMT) is a technique that focuses on enhancing respiratory muscle performance through targeted exercises. Particularly, inspiratory muscle training (IMT) has been found to improve respiratory muscle performance and may reduce exertional dyspnea (Pereira et al., 2019). IMT has been shown to be effective for some types of illnesses or conditions, including respiratory problems, cardiac disorders, and neuromuscular disorders (Dsouza et al., 2021). Although there is research showing a positive impact of IMT in patients with COPD, there is still a need for systematization of knowledge to draw clear conclusions regarding the effect of IMT on respiratory muscle strength, exercise tolerance, dyspnea perception, and the impact on the quality of life of patients with COPD.

Reduced exercise capacity, weakened respiratory muscles, and complaints of dyspnea are all common among COPD patients, leading to a decrease in health-related quality of life (Tkáč et al., 2007). This study aimed to investigate whether the use of IMT can alter the consequences of COPD in patients and provide an updated understanding of the effects of IMT in COPD patients. The specific objectives of the study were to evaluate the effectiveness of IMT on respiratory muscle strength, exercise tolerance, dyspnea, and health-related quality of life in COPD patients.

Methods

Search strategy

For the realization of this literature review are followed the PRISMA guidelines for conducting systematic reviews and meta-analyses, as outlined by Moher et al. (2009). For the purpose of performing this systematic review, the following databases were included: Physiotherapy Evidence Database (PEDro), Google Scholar, and PubMed. Studies conducted within twenty years from 2000 to 2020, were considered. The search was conducted from January to June 2023. Keywords such as respiratory muscle strength, exercise tolerance, dyspnea, and quality of life have been used. A preliminary selection of papers was produced using inclusion criteria based on the information provided in the titles and abstracts. Then, a final selection was made according to an individual critical assessment of the quality of the studies. After identifying potential articles for inclusion in the review, the full texts were thoroughly read to select those that met all inclusion criteria. These selected articles became part of the systematic review. All the phases involved in the search process are illustrated in Figure 1. The evaluation was conducted using the PEDro scale, which evaluates the validity of each study (Table 1).

Inclusion criteria

The inclusion criteria for this study were Randomized controlled trial (RCT) studies, studies with adult participants, studies with diagnosed COPD patients, free studies, studies with specified measures, studies that include IMT therapy, and English-language studies.

Exclusion criteria

Case studies, literature review studies, and studies conducted prior to 2000 were excluded from the analysis.

Results

Quality of the Studies

To assess the methodological quality of the studies included in the systematic review, the PEDro scale developed by the Centre for Evidence-Based Physiotherapy was utilized. The evaluation of the methodological quality was done using the PEDro scale, which rates the studies as outstanding (9–10), good (6–8), fair (4–5), or poor (<4). This systematic review includes seven studies, of which four were of high quality, one demonstrated good quality, and two indicated poor quality, as shown in Table 1. The quality score is based on expert consensus and is intended to eliminate the risk of bias.

Selection and Characteristics of Studies

A total of 134 studies were found by searching through database resources and reviewing reference lists. Finally, the

Table 1. Quality Assessment Using the PEDro Scale

	Items by number on the PEDro Scale											
Article	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Total**
Minoguchi et al. (2002)	N	Y	N	N	N	N	N	N	N	Y	Y	3
Magadle et al. (2007)	N	Y	N	Y	Y	N	Y	Y	N	Y	Y	7
Petrovic et al. (2012)	Y	Y	N	Y	N	N	N	N	N	Y	Y	4
Elmorsi et al. (2016)	Y	N	N	Y	N	N	N	N	N	Y	Y	3
Dellweg et al. (2017)	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Y	8
Wang et al. (2017)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	8
Langer et al. (2018)	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y	8

Note. N: criterion not fulfilled; Y: criterion fulfilled; 1: eligibility criteria were specified; 2: subjects were randomly allocated to groups or to a treatment order; 3: allocation was concealed; 4: the groups were similar at baseline; 5: all subjects were blinded; 6: all therapists were blinded; 7: all assessors were blinded; 8: measures of at least one key outcome were obtained from over 85% of the subjects who were initially allocated to groups; 9: intention-to-treat analysis was performed on all subjects who received the treatment or control condition as allocated; 10: the results of between-group statistical comparisons are reported for at least one key outcome; 11: the study provides both point measures and measures of variability for at least one key outcome; total score: each satisfied item (except the first) contributes 1 point to the total score, yielding a PEDro scale score that can range from 0 to 10.

systematic review comprised a total of seven full-text research articles. Figure 1 depicts the selection procedure for the study. Table 2 lists the seven studies that were part of the systematic review. The majority of scientific research articles selected for in-depth analysis contained one experimental group and one control group. Table 2 shows the findings of the study.

Table 2. Summary Table of the Studies Included in the Systematic Review

Author / Year	Population	Experimental Group	Control Group	Measurements	Results
Minoguchi et al. (2002)	N=12, COPD patients, <78 years of age.	For four weeks, the patients received IMT (two sessions of 10 minutes of training each day at 30% of PImax).	For four weeks, the patients received respiratory muscle stretching (three sessions of five patterns, four times each, daily) for 4 weeks.	Respiratory muscle strength, exercise tolerance.	Muscle strength increased in the IMT treatment group (from 66.1±5.9 to 79.1±6.5 cmH2O; p=0.002), Exercise tolerance increased significantly in the IMT group (from 386±21 m to 412±18 m; p=0.041).
Magadle et al. (2007)	N=34, COPD patients, <68 years of age.	Patients were treated with general reconstructive exercises for 12 weeks and then treated with IMT for 6 months.	Patients were treated with general exercise for 12 weeks and then with sham IMT for 6 months at a load known not to improve inspiratory muscle function.	Respiratory muscle strength, dyspnea, quality of life.	There was a significant increase in respiratory muscle strength in the experimental group (from 66±4.7 to 78 ± 4.5 cm H2O; p<0.01). Dyspnea decreased in the experimental group (from 20.2±0.4 to 14.9±0.3 total Borg score; p<0.001). This was accompanied by a significant improvement in the quality-of-life questionnaire scores.
Petrovic et al. (2012)	N=20, patients with COPD stage II or III, <70 years of age.	IMT treatment sessions were performed by subjects once a day, seven days a week, for eight weeks.	Daily treatment of the inspiratory muscles with strength and endurance exercises was performed by the subjects for eight weeks.	Respiratory muscle strength, dyspnea.	IMT improves respiratory muscle strength (from 7.75±0.47 kPa to 9.15±0.73 kPa, respectively; p< 0.001) and the perception of dyspnea (from 5.0±1.0 to 4.0±1.1; p<0,01).
Elmorsi et al. (2016)	N=60, patients with moderate to very severe COPD, <62 years of age.	Group A received IMT and exercise for the peripheral muscles at a rate ranging from 30 to 60% of their inspiratory pressure.	Only peripheral muscle exercise was administered to Group B. Group C did not receive any care.	Respiratory muscle strength, exercise tolerance, dyspnea, quality of life.	IMT offers COPD extra advantages in terms of respiratory muscle strength and exercise capacity. However, this improvement did not translate into additional improvements in dyspnea and quality of life compared with what is achieved by peripheral muscle exercise training alone.
Dellweg et al. (2017)	N=29, patients with COPD stage III or IV, <74 years of age.	For four weeks, IMT was administered once a day during the workdays.	For four weeks, sham IMT was administered once a day during the workdays.	Respiratory muscle strength, exercise tolerance	IMT improves exercise capacity and increases respiratory muscle strength and power.
Wang et al. (2017)	N=81, patients with stable COPD, <40 years of age.	For eight weeks, IMT was combined with a CET.	For eight weeks, there were two treatment groups: the CET group used a cycle ergometer, whereas the control group was treated with free walking.	Respiratory muscle strength, exercise capacity, dyspnea, quality of life.	The experimental group showed improvements in respiratory muscle strength, exercise capacity, dyspnea, and quality of life (p<0.05).
Langer et al. (2018)	N=20, patients with stable COPD, <77 years of age.	For eight weeks, the IMT group worked out twice a day at a training intensity of 40 to 50% of Pimax.	The treatment involved performing 30 breaths twice to three times a day for four to five minutes each, seven days a week for eight weeks.	Respiratory muscle strength, dyspnea.	IMT improves respiratory muscle strength and dyspnea (p<0.05).

Note: CET=cycle ergometer, PImax=maximum inspiratory, kPa=kilopascal, cmH2O=centimeters of water, m=meter.

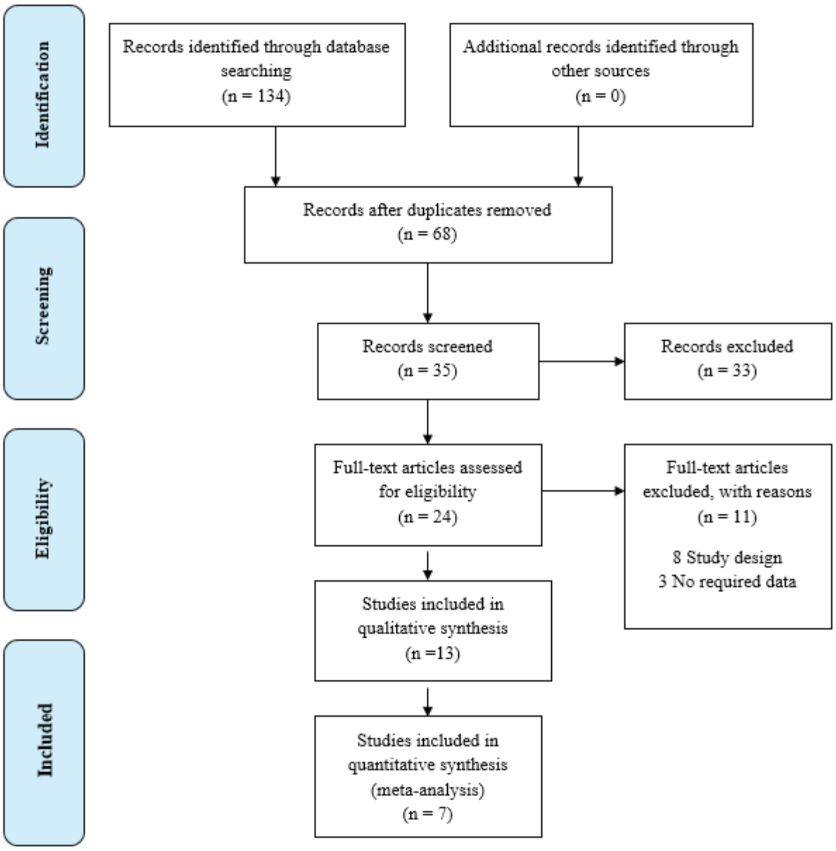

FIGURE 1. PRISMA Study flow diagrams

Discussion

Respiratory muscle strength

In most studies, respiratory muscle strength was measured using the maximum inspiratory pressure (PImax) and maximal expiratory pressure (PEmax). According to the study by Wang et al. (2017), the group that received treatment with a cycle ergometer and IMT showed a substantial increase in Pimax and PEmax (P<0.05). As per Dellweg et al. (2017) study, only patients in the IMT group who were determined to have increased inspiratory muscular strength, as measured by PImax, showed significant improvement. Additionally, at the end of weeks two and four, these patients also demonstrated a decrease in maximum negative inspiratory pressure. As reported by Petrovic et al. (2012), after 8 weeks of daily IMT, the IMT training group exhibited a significantly greater degree of inspiratory muscle performance. PImax increased by 18% (P<0.001). Elmorsi et al. (2016) found that IMT combined with peripheral muscle exercise training enormously improved PImax and PEmax (P= 0.000). Based on the study conducted by Minoguchi et al. (2002), respiratory muscle strength, as measured by PImax, showed a notable increase in the IMT treatment group (p=0.002). As specified by Langer et al. (2018), measures of respiratory muscle strength in the IMT group demonstrated significant post-intervention changes (P<0.05). According to Magadle et al. (2007), after three months of training, there was a substantial difference in the PImax in the IMT training group, and this difference was maintained after a further three months of training.

Exercise tolerance

In the majority of the studies, exercise tolerance was measured using the 6-minute walk test (6 MWT). As indicated by Wang et al. (2017), exercise capacity was evaluated using the 6-minute walk test (6MWT) and a maximal exercise test. The group that received cycle ergometer + IMT treatment indicated substantial increases in the 6MWT from baseline (p<0.05). As evidenced by Elmorsi et al. (2016), 6MWD significantly increased in the IMT+peripheral muscles exercise treatment group (p=0.000). Six-minute walking distance considerably increased following treatment in the group receiving IMT, as shown by Minoguchi et al. (2002) (p=0.041). According to Dellweg et al. (2017), the 6-minute walk test (6MWT) showed noticeable improvement in the IMT group by week 2. By the end of the study, patients in the IMT group had walked a longer distance than those in the sham IMT group.

Dyspnea

The Borg Scale was used to measure dyspnea perception in the majority of the studies. Petrovic et al. (2012) study revealed that the level of dyspnea assessed with the BORG Scale showed a notable decrease (p<0.01). As reported by Magadle et al. (2007), the perception of dyspnea in the IMT treatment group significantly decreased (p<0.001). As stated in the study conducted by Langer et al. (2018), dyspnea in the IMT group improved after 8 weeks, despite no significant changes in ventilation, breathing pattern, or lung function. The relief of dyspnea was accompanied by a decrease in diaphragm activation compared to the maximum level. The study conducted by Wang et al. (2017) utilized the COPD Assessment Test (CAT) and the modified mMRC (Modified Medical Research Council) Dyspnea Scale to assess the severity of dyspnea. The results showed that the group that underwent cycle ergometer + IMT treatment experienced a significant reduction in dyspnea compared to the control group (p<0.05). The findings of Elmorsi et al. (2016) found that the group receiving IMT + peripheral muscle exercise therapy had a considerably decreased dyspnea rate, as measured by mMRC (p=0.001).

Quality of life

In most studies, the measurement of health-related quality of life was conducted using the St. George's Respiratory Questionnaire (SGRQ). According to Wang et al. (2017), the health-related quality of life, as measured by SGRQ, in the group that received cycle ergometer + IMT therapy showed substantial improvements in quality of life, depression, and anxiety (p<0.05). Treatment with IMT+ peripheral muscle exercises significantly improved SGRQ-C questionnaire domains, as shown by Elmorsi et al. (2016) (p=0.000). The SGRQ score in the IMT treatment group reportedly decreased steadily, according to Magadle et al. (2007). At the end of the sixth month of training, the difference between the IMT-treated group and the sham IMT group became significant (p<0.05).

Findings from studies that were not included in the review

Numerous studies have investigated the effects of IMT on muscle strength, and the majority have demonstrated that treatment with IMT significantly increases the strength of respiratory muscles in COPD patients (Geddes et al., 2005; Geddes et al., 2008; Gosselink et al., 2011; Lötters et al., 2002; Beaumont et al., 2018; Schultz et al., 2018). Regarding the effect of IMT on exercise tolerance, several studies have confirmed our findings that IMT increases exercise capacity in COPD patients (Riera et al., 2001; Lötters et al., 2002; Geddes et al., 2008; Shoemaker et al., 2009; Gosselink et al., 2011; Beaumont et al., 2018). Other research studies have corroborated our findings regarding the reduction in dyspnea perception following the treatment of COPD patients with IMT (Riera et al., 2001; Lötters et al., 2002; Geddes et al., 2005; Geddes et al., 2008; Shahin et al., 2008; Shoemaker et al., 2009; Gosselink et al., 2011; Beaumont et al., 2018). The effectiveness of IMT in improving health-related quality of life has been confirmed in several studies (Riera et al., 2001; Gosselink et al., 2011; Beaumont et al., 2018).

Strength of the study

The study provides detailed information to explain the effects of IMT in patients with COPD. The data collection was cost-effective, the data are relatively easy to analyze, and also the data are very consistent, accurate, and reliable. Another strength of the study is that the findings can be generalized.

Limitations of the study

As with any scientific research or literature review, we encountered various limitations when producing this article. Firstly, the studies had different treatment protocols, including variations in the type of IMT used and its association with other methods, even within the experimental groups. The diversity of comparability and reliability would be higher in studies with homogeneous groups that follow standardized treatment procedures. Secondly, conducting studies on patients in the same stages of COPD, where each objective mentioned above is studied separately for distinct classes, would yield significant statistical results. This would help estimate the IMT for each stage of COPD. Thirdly, due to financial constraints, we have been unable to acquire many valuable articles that are relevant to our research goals. As a future research direction, several studies can be conducted to provide useful evidence on the effectiveness of IMT in different stages of the disease. Additionally, standardized IMT treatment protocols can be developed for patients with COPD.

Conclusions

This systematic review has highlighted the efficacy of IMT in improving outcomes for patients with COPD. According to the evidence gathered from the literature review, IMT therapy has been shown to improve respiratory muscle strength, exercise tolerance, perception of dyspnea, and health-related quality of life in COPD patients. It is necessary to conduct studies using high-quality, evidence-based data to draw more definitive conclusions about the effectiveness of IMT. Future research should examine whether these improvements are applicable to all COPD patient groups. Additionally, it should explore the long-term effectiveness of these therapeutic improvements and determine which IMT treatment protocol provides the most significant clinical benefits.

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Conflict of interest
The authors declare that there are no conflicts of interest.

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