REVIEW PAPER

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Effect of electromagnetic field therapy in chronic respiratory disease: systematic review

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Abstract

Introduction. Pulmonary function and functional capacity decline in chronic respiratory diseases, especially in chronic obstructive pulmonary disease. Physiotherapy is an integral part of treating respiratory patients since it helps combat muscle depletion and respiratory symptoms. Nevertheless, the knowledge about applying electromagnetic field (EMF) therapy as a therapeutic option in chronic respiratory patients is minimal. So, the aim of this review is to determine the effect of Electromagnetic Field Therapy on Pulmonary Function and 6-minute walk distance in chronic respiratory disease patients.

Methods. The PubMed, PeDRO, Scopus, COCHRANE, and Web of Science databases were searched and randomised control trials investigating EMF on pulmonary function and 6MWT distance in a chronic respiratory disease population, published before January 2022, were selected. Three reviewers assessed each study's quality after data were extracted into a trial description form.

Results. Three studies met the inclusion criteria on pulmonary function and 6MWT distance. The sample size ranges from 10 to 37 for EMF. The improvement in pulmonary function was not significant in FEV_1, FEV_1/FVC and significant in PEF versus control. The change in 6MWT distance was 21.68 m, which is a clinically significant change.

Conclusions. EMF therapy has been shown to improve pulmonary function and 6MWT distance. The study was the first to examine and synthesise existing EMF data.

Key words: electromagnetic field, COPD, asthma, magnetic stimulation, chronic respiratory disease

Introduction

Chronic respiratory disease (CRD) accounts for a significant worldwide disease burden. Diseases associated with chronic respiratory distress are among the most common causes of mortality and morbidity, with chronic obstructive pulmonary disease (COPD) and asthma being the most common. Each has some degree of inflammation as the primary cause of disease progression. Every iteration of the Global Burden of Illness survey has indicated that COPD and asthma are substantial contributors to the fatal and non-fatal illness burdens, respectively, and are increasing in prevalence. These diseases were ranked 8th (COPD) and 23rd (asthma) in terms of disease burden, which was measured in terms of disability-adjusted life years (DALYs), among the top causes of disability in the world. Although these diseases are preventable and treatable with low-cost interventions, they have received less attention than non-communicable diseases [1, 2].

Inflammation is being treated using pulsed electromagnetic fields (PEMFs), showing promise as a new therapy option. These fields have the potential to have significant impacts on tissue regeneration. The PEMF controls inflammatory processes by modulating pro-and anti-inflammatory cytokines at various phases of the inflammatory response. Researchers have discovered that employing PEMF as an alternative or supplemental therapy to pharmacological medicines may provide consistent results in animal and human tissue studies. Consequently, PEMF therapy may provide a unique nonpharmaceutical method of controlling inflammation in diseased tissues, resulting in improved functional recovery [3].

Researchers' interest in electromagnetic fields (EMFs) is still present today, as seen by more recent articles indexed in the National Library of Medicine in the United States [4–7]. EMFs may have anti-inflammatory properties [8] and analgesic impact owing to their tendency to induce vasodilation, myorelaxation, and ion exchange modulation across the cell membrane [9, 10]. EMF offers a prospective therapy or an alternative therapeutic intervention for a wide variety of disorders, although its application in respiratory patients is currently entirely restricted, given the lack of solid evidence. Even though electromagnetic field therapy (EMFT) is often applied in physiotherapy, little is known regarding its potential therapeutic value in the treatment of asthma and COPD. For patients with respiratory illnesses, there are few published evaluations or assessments of the use of EMFT. Accordingly, this review aimed to study the effect of EMFs on pulmonary function in patients with COPD and asthma. Patients with COPD were also evaluated to determine if their 6-minute walk distances were affected by exposure to electromagnetic fields (EMFs).

Review question: Does electromagnetic field therapy affect pulmonary function and 6-minute walk distance in chronic respiratory disease patients?

Subjects and methods

Systematic review

The quantitative systematic review protocol was prospectively registered with PROSPERO (CRD42022307550).

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In January 2022, a systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [11]. Articles from multiple databases, including Scopus, PubMed, PEDro, Web of Science, and COCHRANE, that had a target population suffering from COPD and/or asthma were obtained. The articles were chosen using the PICOS qualifying criteria (participants, intervention, comparator, outcomes, study design).

Participants were both male and female of any age group, and the intervention was Electromagnetic Field Therapy delivered for chronic respiratory disease patients. The comparator was any comparator or sham/control that did not include pharmacological therapy.

The search strategy included the term 'Pulsed electromagnetic field', 'electromagnetic field', 'magnetic field', 'magnetic stimulation', 'diathermy', 'thermal effect', 'radio wave', 'COPD', 'Chronic obstructive pulmonary/airway/lung' or 'respiratory disease', 'emphysema', 'chronic respiratory disease'. The boolean terms AND and OR were used to concentrate the search terms. The authors considered articles published in the English language only for this review. The reference lists of each included paper and relevant reviews and guidelines were manually searched. We contacted the writers if extra information was required.

Search

(COPD AND Pulsed electromagnetic field), (Chronic obstructive Pulmonary/airway/lung/respiratory disease AND Pulsed electromagnetic field), (COPD AND electromagnetic field), (Chronic obstructive Pulmonary/airway/lung/respiratory disease AND electromagnetic field), (COPD AND magnetic field), (Chronic obstructive Pulmonary/airway/lung/respiratory disease AND magnetic field), (COPD AND magnetic stimulation), (Chronic obstructive Pulmonary/airway/lung/respiratory disease AND magnetic stimulation).

Validated techniques were used to measure Pulmonary Function and randomised controlled trials were required for the research.

Study design

Only RCTs were included in the evaluation.

Participants

Inclusion: Male and female patients of any age group with chronic respiratory disease (there was no upper age limit) and treatment given at any stage of the disease (acute or chronic).

Exclusion: Studies for diagnostic purposes, non-RCTs, observational, cross-sectional studies.

Interventions and comparators

Studies of electromagnetic field treatment or stimulation were included. Intervention combinations were not included (e.g., Laser, Photo-biomodulation). Comparators included a control intervention, a sham intervention, and conventional pharmacological therapy.

Outcome measures

Pulmonary Function Test was the key outcome measure. The Six-Minute Walk test distance was the secondary outcome.

Study selection

The references were exported to the Mandley reference manager software when the search was completed, and duplicates were detected and removed. Two reviewers (GJ and DM) independently assessed the remaining titles and abstracts against the inclusion criteria, and inclusion was verified by discussion and consensus.

Quality assessment

As suggested by the Cochrane Guidebook for systematic reviews of interventions, the Cochrane risk of bias tool was used to evaluate the included studies [12, 13]. The PEDro scale was used to assess the Randomised Controlled Clinical Trials (RCTs) [14]. This is an 11-item scale intended to assist users in quickly assess internally valid trials (criteria 2–9) and contains enough statistical information to aid clinical decision-making (criteria 10–11). Simply calculating how many provided criteria were clearly met in the trial report produces a score ranging from 0 to 10. Based on this interpretation, the greater the result, the stronger the methodological quality and the lesser the bias potential [15].

Results

Six hundred and sixteen (616) articles were identified, and 451 were examined based on their title and abstract after duplicates were removed (Figure 1). These were reviewed based on the inclusion criteria, and 417 irrelevant studies were excluded. The entire text was obtained and reviewed if there was any doubt about the study's eligibility based on the title and abstract. Two researchers (GJ and DM) devised the search technique, who sought advice from a third researcher (ARK) whenever they disagreed. Following an initial examination, 34 papers were identified as possibly relevant, and their entire texts were thoroughly examined, with specific emphasis on the intervention (kind of therapy), changes in PFT and 6MWTD, number of sessions, and length of treatment. Finally, four papers were determined by identifying the aim and criteria for this evaluation. Figure 1 depicts the rationale for selecting papers that met the research goals and inclusion/exclusion criteria. The last three articles included a total of 94 persons. Tables 1 and 2 provide a short summary of each included study.

Interventions or treatment

Pulmonary function:

1. COPD and asthma: An MTU 500H (Therapy System, Brno, Czech Republic) provided a pulsatile electromagnetic field to adults with CRD on the thorax. The dosage was given in ten doses, once a day for 20 minutes. The electromagnetic field had a frequency of 4.5 Hz and a magnetic induction of 3 mT, and the first three doses were about 25% less than the complete dosages that followed. The manufacturer advised these dosages (Biotrop's parameters for the MTU 500H).

2. Asthma: An M 500H apparatus (Therapy System, Brno, Czech Republic) was used to apply a pulsatile electromagnetic field to children for 5 days, twice a day, for 10 minutes, with a magnetic induction of 3 mT and a frequency of 4 Hz.

Six-Minute Walk Test

COPD: A Medtronic Magpro electromagnet (Medtronic Denmark A/S, Copenhagen, Denmark) with 60 mm radius

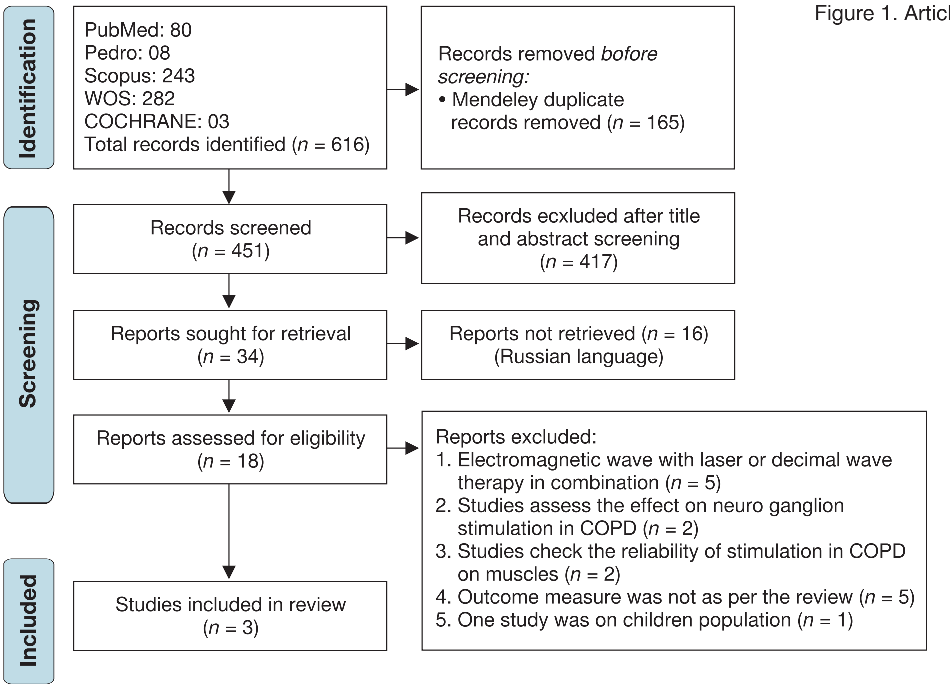

Figure 1. Article-selection flowchart (PRISMA)

Table 1. Study and participant features

Author, year	Type of research	Sample Size (participants)	Disease	Indicators of change	Results
Bustamante et al. (2008) [16]	Randomised clinical trial	COPD ($n = 10$) Control ($n = 5$)	Stage 4 (GOLD)	Oxidative stress and 6MWT	An individual percentage change in walking distance was significantly correlated with baseline muscle protein carbonylation levels ($r = -0.767$, $p = 0.016$) in the group of patients who underwent magnetic stimulation training
Bustamante et al. (2010) [15]	Randomised clinical trial	COPD ($n = 10$) Control ($n = 8$)	Stage 3 & 4 (GOLD)	MVC, 6MWT, QOL	6MWT distance increased by 23.4 m (CI: 11; 36) compared to the control group's –6 m (CI: –18; 24)
Sadlonova et al. (2002) [9]	Randomised clinical trial	COPD PEMF ($n = 16$) Control ($n = 24$) Asthma PEMF ($n = 37$) Control ($n = 40$)	Diagnosis was based on BTS (1997)	PFT (FEV_1, FVC, PEF and MEF 25–75%)	– In patients with COPD and with applied PEMF, all PFT values showed statistical significance, except for FVC – In asthma patients, PEMF did not show statistical differences in measured PFT values

PEMF – Pulsed Electromagnetic Field Therapy, BTS – British Thoracic Society, 6MWT – Six-Minute Walk Test, PFT – Pulmonary Function Test, MVC – Maximal Voluntary Contraction, QOL – Quality of Life, FVC – force vital capacity, FEV_1 – force expiratory volume in 1 s, $MEF_{25–75\%}$ – mean expiratory flow 25, 50 and 75%, PEF – peak expiratory flow

Table 2. Study interventions' characteristics

Author, year	Description (intervention)	Duration of sessions	Dosage
Bustamante et al. (2008) [16]	– 60 mm Refrigerated MCF 125 circular stimulating coil of a Medtronic Magpro (Medtronic Denmark A/S, Copenhagen, Denmark) – The coil head was placed on the upper portion of the quadriceps, over the rectus and vastus lateralis	15 min/day for 3 days/week for 8 weeks	– The magnetic stimulation intensity of the stimulator was gradually raised from 40% to 70% of the maximum output – The frequency was lowered from 15 to 8 Hz as the intensity was increased
Bustamante et al. (2010) [15]	– 60 mm Refrigerated MCF 125 circular stimulating coil of a Medtronic Magpro (Medtronic Denmark A/S, Copenhagen, Denmark) – Patients sat or reclined with their knees flexed to 90 degrees and ankles strapped	15 min/day for 3 days/week for 8 weeks	– Stimulation was ON for 2 s and OFF for 4 s for bursts of twitches – Intensity was in between 40% and 70% – Stimulation started at 40% at 2T at 15 Hz and ended at 70% at 2T at 7 Hz
Sadlonova et al. (2002) [9]	MTU 500H (Therapy System, Brno, Czech Republic)	10 sessions/20 min 1 session/day	– 4.5 Hz and 3 mT – Initial 3 administrations were about 25% lower in strength than the later full doses

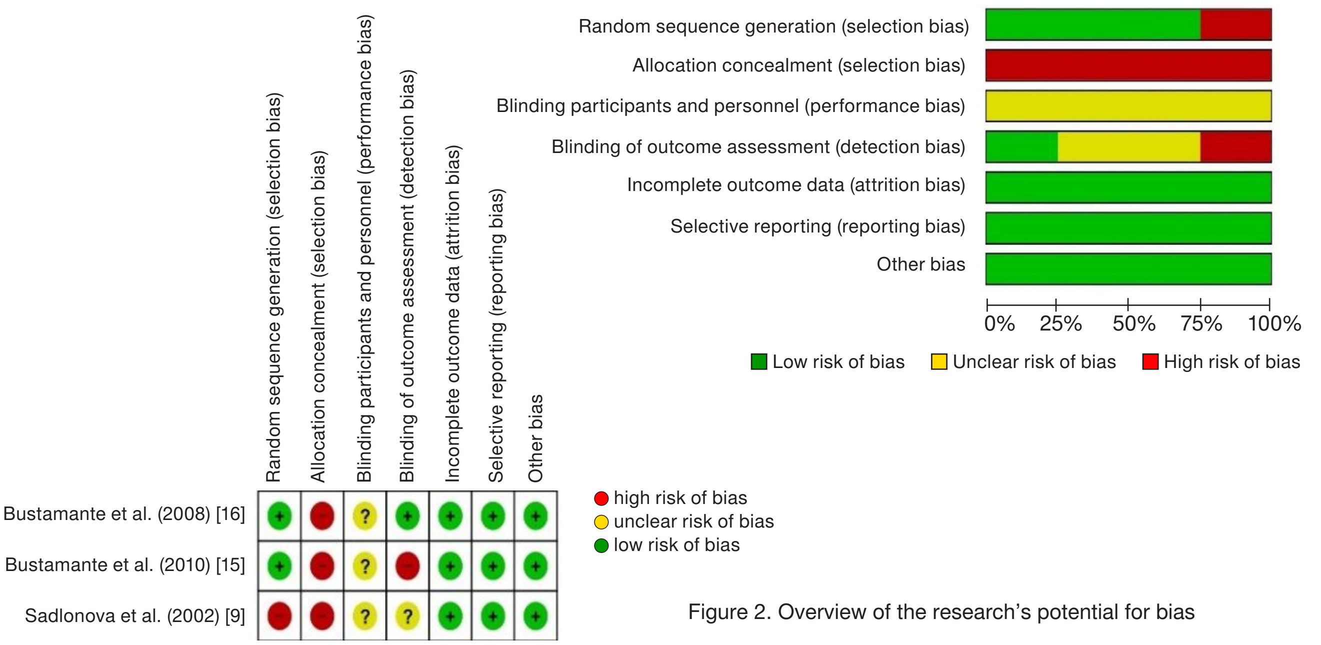

Figure 2. Overview of the research's potential for bias

MCF 125 circular stimulation coils was used to stimulate the quadriceps muscle magnetically. Quadriceps muscles in both lower limbs were activated in these patients. On the quadriceps muscle's superior third (over the rectus and vastus lateralis), a small coil head was positioned with minor alterations to establish an appropriate location in each lower limb. Once this position was established, it was used for the duration of the eight-week procedure, which included three 15-minute sessions of quadriceps muscle stimulation each week. As tolerated, the magnetic stimulation intensity was gradually increased from 40% to 70% of the stimulator's maximal output with 2T of magnetic induction. As a result, the frequency was decreased as the intensity grew (2% to 3% after every two sessions), ranging between 15 and 7 Hz, to avoid overheating the coil (15 Hz at 40% and 7 Hz at 70%). The stimulation was administered on an intermittent basis, with 2 s of ON and 4 s of OFF.

Methodological quality of the included articles

Two of the three studies [16, 17] included in this review were assessed to have a score of 7 or higher (Table 3). These are the ones that have a high degree of methodological integrity. The remaining one article [9] scored the lowest, with a score of 6. Many of the criteria for acceptance were not met by these articles, calling into question the high standard of the methodology for RCTs, as no allocation was made, and neither the therapists nor the assessors were blinded to the study, except for Bustamante et al. in 2008 [16], where only the assessor was blinded. As a result, the dependability of these studies is called into question. The Cochrane risk of bias [12, 13] was also applied to analyse the studies that were included in the evaluation (Figure 2).

The existing low-quality data show that EMF treatment may enhance pulmonary function clinically, particularly in PEF. Given the general health advantages of EMF and the minimal risk of documented adverse effects (no side effects were observed), COPD patients may consider utilising it for improved lung function either alone or in combination with other therapy options.

Table 3. Summary of the quality of the randomised clinical trials included in this review based on the PEDro scale

Criteria	Bustamante et al. (2008) [16]	Bustamante et al. (2010) [15]	Sadlonova et al. (2002) [9]
Eligibility	Y	Y	Y
Randomly allocated	Y	Y	×
Concealed allocation	Y	Y	Y
Baseline comparability	×	×	×
Blind subjects	×	×	×
Blind therapists	Y	×	×
Blind assessors	Y	Y	Y
Adequate follow up	Y	Y	Y
Intention to treat	Y	Y	Y
Between-group comparisons	Y	Y	Y
Point estimates and variability	Y	Y	Y
Total	8	7	6

Y – yes

Discussion

The use of EMF as a treatment for musculoskeletal system dysfunctions and pain has a long history and its effectiveness has been supported by various research [19–21]. Because of the limited scope of the research, we could not find any previous reviews on using EMF in respiratory patients. COPD is a disabling illness that predominantly impairs respiratory and motor functioning during acute and chronic phases. According to the studies, to address COPD's underlying symptoms, including dyspnoea and muscular depletion, pulmonary rehabilitation is the most often recommended and most effective treatment approach [22–24].

A proper design of rehabilitation activities for COPD patients is essential to lower the high hospital readmission rate in this group [25, 26]. An EMF programme involving stimulation with a suitable intervention length of 8 weeks and 5–10 days improved lung function and exercise capacity in COPD and asthma patients. The intervention's impact on pulmonary function, on the other hand, was unclear since only a small number of RCTs reported these results.

This study aimed to analyse the evidence for EMF on pulmonary function and 6MWT distance in diverse chronic respiratory illness populations (COPD and asthma). Following EMF, a minor and non-significant rise in FEV_1, the FEV_1/FVC ratio, and PEF was seen, indicating an improvement. There was no indication that EMF influenced $MEF_{25\%–75\%}$ or FVC. Because EMF is a feasible intervention for improving pulmonary function, it is critical to evaluate its efficacy in a clinical population.

According to the research analysed, EMF appears to have a favourable impact on COPD patients, notably those by Sadlonova et al. [9, 17], in which pulsatile electromagnetic fields improved respiration and mucociliary clearance in patients compared to those who received a placebo therapy. Only patient-reported data was utilised to quantify the volume and density of mucus in this investigation, limiting its ability to evaluate mucus clearance accurately. Spirometry measurements such as FEV_1, the FEV_1/FVC ratio, and Peak Expiratory Flow (PEF) improved the quantitative data; however, there was no statistically significant impact on the overall lung function except for PEF. It is not clear from this study's evidence analysis whether EMF impacts the airways (i.e., inhibits airway remodelling) or the lung parenchyma (i.e., avoids alveolar damage). The paucity of data on the efficacy of EMF on respiratory symptoms needs deeper experimental research, particularly given that peripheral muscle function is well accepted as a link with disease severity.

According to the data acquired from the retrieved citations, EMFs are often applied to improve muscular function, as shown in the research by Bustamante et al. [15, 16]. One of the most incapacitating disorders in COPD patients is quadriceps muscle weakness, which results in exercise restriction and, as a consequence, lowers motor activity. One of the most intriguing features of this analysis is that EMF seems to have a favourable impact on expanding the size of the quadriceps fibres in COPD patients [17]. Lower limb muscle movement and all other motor skills associated with everyday living tasks are critical biomechanical components of walking. Changes in functional capacity and lower limb functional improvement post-EMF application were assessed by 6MWT, and were shown to improve by 21.68 m, which is less than the Minimal Clinical important Difference (MCID) but it is clinically relevant in this population. The change in the 6MWT distance was nearly close to the MCID of 30 m in COPD post pulmonary rehabilitation with lower-limb endurance training [27]. As a result, a specific therapy aimed at improving muscular strength is precisely in line with the peculiarities of COPD and the demands of patients. Electrical muscle stimulation, on the other hand, is an effective method for preventing muscle atrophy in a variety of populations, including COPD patients [28, 29].

Conclusions

This study aimed to examine and synthesise existing EMF data to identify its influence on pulmonary function and 6MWT distance. The existing low-quality data show that EMF stimulation, primarily pulsed, may produce clinically substantial symptom relief with no adverse effects. Despite the heterogeneity in the intervention methods and populations, the meta-analysis revealed a minor but statistically significant increase in PEF and the FEV_1/FVC ratio after EMF. Only a few studies included outcome measurements of 6MWT distance with evidence to show a change in distance walked measures after EMF stimulation.

Limitations

Considering the lack of studies, number of participants, different age groups, population and study design, the results of the studies cannot be implemented in clinical practice. It requires high impactful RCTs to assess the effect of EMF in respiratory diseases.

Study implication and future recommendation

A new non-pharmacological treatment option that has shown great potential in treating inflammation and promoting healing, EMF showed a mildly promising result in improving pulmonary function with good clinical subjective outcomes. However, the reason for the changes and mild differences has not yet been explained, and further studies with high-quality RCTs are required to gain insight into the effects of electromagnetic fields on parenchyma of the pulmonary system.

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Ethical approval

The conducted research is not related to either human or animal use.

Disclosure statement

No author has any financial interest or received any financial benefit from this research.

Conflict of interest

The authors state no conflict of interest.

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