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Magnetic Stimulation Therapy in Patients with COPD: A Systematic Review

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ABSTRACT

Magnetotherapy (MT) is a therapeutic treatment based on the use of magnetic fields (MF) that can have an anti-inflammatory and analgesic effect. MT represents a possible treatment or an ancillary therapeutic intervention for a wide range of diseases and it is often used in the field of physiotherapeutic practices. A crucial point in the treatment of chronic obstructive pulmonary disease (COPD) patients, to counteract muscular depletion and respiratory symptoms, is represented by physiotherapy. Nevertheless, the knowledge about the application of MF as a therapeutic option in COPD patients is very limited. The purpose of the present study was to define what is currently known about the use of MF in patients with COPD. A systematic review of the literature was conducted during the month of October 2017, searching three main databases. Only those citations providing detailed informations about the use of MF to treat COPD symptoms either during an acute or a chronic phase of the disease, were selected. Following the selection process three articles were included in the final analysis. The present review focused on a total of thirty-six patients with COPD, and on the effects of the application of MF. In the majority of cases, the treatment sessions with MF were carried-out in an outpatient setting, and they differed with regard to the duration; frequency of application; dosage; intensity of the applied MF. Basing on the available informations, it seems that MF is a feasible, well tolerated, safe therapeutic option, for the treatment of motor-related COPD symptoms.

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Introduction

Magnetotherapy (MT) is a therapeutic treatment based on the use of magnetic fields (MF) to maintain health and treat illness. Starting from 1960s, the interest on this technique has increased, and its use as well as its diffusion have reached the maximum mostly in the Eastern European countries (most of the publications about this topic are in Russian language) where the MT was firstly applied for the treatment of different pathological conditions, including chronic pain, and acquired bone nonunion (1–12).

Researchers' interest on the use of MT still continue nowadays, as confirmed by more recent publications indexed in the US National Library of Medicine (13–16). MF can have an anti-inflammatory (17) and analgesic effect thanks to their ability to induce vasodilatation, myorelaxation, and modulation of ion exchange across cell membrane (18,19). Therefore, MT represents a possible treatment or an ancillary therapeutic intervention for a wide range of diseases, but its use in respiratory patients is still very limited, given the lack of consistent evidence. The most common respiratory disease is chronic obstructive pulmonary disease (COPD) (20–23). Typically, patients with COPD experience shortness of breath, reduced exercise tolerance, and worsening of quality of life (24). The relevance of rehabilitation for the treatment of this class of patients is well known (25–28), and an increasing interest is mounting also about the feasibility of a home-based modality (29–31); although MF are used in physiotherapeutic practices, the knowledge about the application of MF as a therapeutic option in COPD patients is very limited. To date there are not published reviews examining the application of MF in COPD patients, and very few studies are available in the literature regarding magnetic stimulation for patients with respiratory diseases. The purpose of the present study was to define what is currently known about the use of MF in patients with COPD.

Methods

A systematic review of the literature was conducted during the month of October 2017, searching three main databases: US National Library of Medicine (PubMed), Scopus, and Web of Science.

Search strategy

Due to the very narrowed nature of the topic, it has been chosen a search strategy that allowed to retrieve the highest number of results, using two key words: 'magnetic fields' and 'COPD' linked by the Boolean operator AND. Search was conducted in the title and abstract fields for each database. No limits were used for the date of publication.

Inclusion and exclusion criteria

Only papers written in English, French, Italian, or Spanish were included; moreover, only those citations providing detailed

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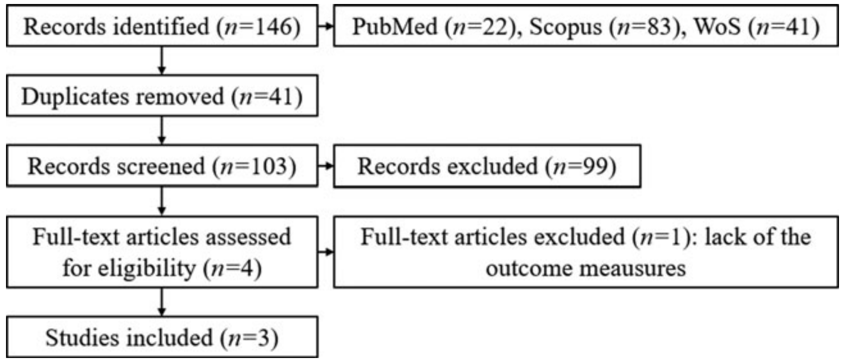

Figure 1. Flow chart.

information about the use of MF to treat COPD symptoms either during an acute or a chronic phase of the disease, were selected. Abstracts, opinion pieces, letters to the editors, and conference proceedings were not considered suitable for the inclusion in the present review. Those citations discussing the use of MF in COPD patients as a diagnostic instrument, were also considered not suitable for inclusion.

Studies selection

Two reviewers independently revised the literature according to the abovementioned criteria; they operated a selection of the citations, and then a consensus for the final inclusion has been reached. Studies describing the use of MF in COPD patients were included. A case report, describing the use of MF in a COPD patient, was initially considered suitable for inclusion (32), but it was excluded after the full-text analysis due to the lack of outcome measures, and in accordance with the exclusion criteria (Figure 1). A full-text analysis of the included articles was performed and the results are shown below.

Results

A total of one hundred forty-six citations published in the selected databases up to October 2017 has been found; after the selection process three articles were included in the final analysis, as shown in Figure 1. All those three papers have been published in the last fifteen years; two out of three were randomized controlled trials (33,34).

MF application

In one case (18), the study design was not defined by the authors: we considered it as an interventional study (35) with subjects allocated in four arms. In that study patients with COPD were allocated in two arms treated with a placebo or with sessions of pulsatile electromagnetic fields, respectively. Magnetic stimulation was performed once daily for 20 minutes for 10 days using the apparatus MTU 500H (Therapy System, Brno, Czech Republic): however, it was not described how MF were applied to the body.

MF applied to lower limbs

The remaining studies by Bustamante and Colleagues (33,34) included two groups: in the control group the COPD patients followed a clinical monitoring, while in the treatment group they underwent to stimulation of quadriceps of both lower limbs, using the apparatus Medtronic Magpro electromagnet (Medtronic Denmark A/S, Copenhagen, Denmark; provided with a 60-mm refrigerated MCF 125 circular stimulating coil). In both studies the treatment was applied in 15-minute sessions, with the intensity and frequency of stimulation adjusted according to patient's tolerance (Table 1).

Table 1. Demographics characteristics of patients with COPD ($n = 36$) treated with MF, and description of the intervention.

	Studies		
Variables	Bustamante et al. (2010)	Bustamante et al. (2008)	Sadlonova et al. (2002)
Female (n. of)	—	—	4
Male (n. of)	10	10	12
Age (years)	$61 \pm 6^{*}$	$59\ (8)^{\S}$	$54 \pm 4^{¥}$
BMI (kg/m^2)	$25.3 \pm 3.8^{*}$	$26.4\ (6.3)^{\S}$	—
GOLD classification (stage)	III–IV	IV	—
Tiffeneau Index (%)	$32 \pm 8^{*}$	$31\ (10)^{\S}$	—
6MWD (meters)	$397 \pm 138^{*}$	$440\ (188)^{\S}$	—
Study design	RCT	RCT	Interventional
Setting	Out-patient	Out-patient	In-patient
MS sessions (n. of)	24	24	10
Type of treatment	Quadriceps MS with coils	Quadriceps MS with coils	PEMF
Dosage	15–7 Hz; 40–70% of the max. output (0.8–1.4 T)	15–8 Hz; 40–70% of the max. output	4.5 Hz; 3 mT
Frequency	3 days/week for 8 weeks	3 days/week for 8 weeks	daily

COPD = chronic obstructive pulmonary disease; **MF = magnetic fields**; **BMI** = body mass index; **GOLD** = global initiative for chronic obstructive lung disease; **6MWD** = six-minute walking distance; **RCT** = randomized controlled trial; **MS** = magnetic stimulation; **PEMF** = pulsatile electromagnetic fields; **Hz** = Hertz; **T** = Tesla; **mT** = milliTesla.
* Mean ± standard deviation; § median (interquartile range); ¥ mean ± standard error of mean (S.E.M.).

Table 2. Main results using MF in patients with COPD ($n = 36$).

Variables	Studies		
	Bustamante et al. (2010)	Bustamante et al. (2008)	Sadlonova et al. (2002)
Motor function-related parameters			
6MWD (meters)	Increased by 23.4*	Increased by 25§	—
Vastus lateralis type I fibers size (μm^2)	—	Increased by 734.2§	—
Quadriceps TwQ (%)	Increased by 15.6*	—	—
Quadriceps MVC (%)	Increased by 17.5*	—	—
Quadriceps endurance (seconds)	Increased by 158*	—	—
Quality of life			
SF-36 (score)	Significant improvements in the following fields: physical functioning, role limitations due to physical problems, bodily pain, social functioning, mental health, role limitations due to emotional problems, vitality, general health perception, changes over time.	—	—
SGRQ (score)	Significant improvements in all four areas.	—	—
Lung function-related parameters			
FVC (L)	—	—	Decreased by 0.03*
FEV1 (L)	No significant differences	—	Increased by 0.27*
Tiffeneau Index (%)	No significant differences	—	Increased by 7.50*
PEF (L/min)	—	—	Increased by 0.66*

MF = magnetic fields **COPD** = chronic obstructive pulmonary disease; **6MWD** = six-minute walking distance; **μm^2** = micrometer; **TwQ** = twitch tension (Kg); **MVC** = maximal voluntary manoeuvres (Kg); **SF-36** = short form; **SGRQ** = St. George's respiratory questionnaire; **FVC** = forced vital capacity; **FEV1** = forced expiratory volume in 1 second; **PEF** = peak expiratory flow.
* Mean; § median.

The present review focused on a total of thirty-six patients with COPD, and on the effects of the application of MF. The main outcomes investigated in the included studies were quadriceps muscle function (*i.e.*, structure, strength, and endurance), exercise capacity (6MWD), health-related quality of life, and pulmonary function tests, as summarized in Table 2. For twenty subjects, the diagnosis of COPD was sustained by the GOLD guidelines and Tiffeneau Index measured at baseline. Demographics data and other characteristics of the patients are illustrated in Table 1. In the majority of cases, the treatment sessions with MF were carried-out in an outpatient setting, and they differed with regard to the duration; frequency of application; dosage; intensity of the MF applied; and type of device used, as shown in Table 1. MF were primarily used for the muscle stimulation of the quadriceps resulting in increased walked distance, muscular strength, and endurance after treatment; additional improvements were also detected in the quality of life domains (Table 2).

Discussion

The use of MF as a therapy for dysfunctions and pain of the musculoskeletal system has a long-term history, it is a solid concept, and its efficacy is sustained by several studies (36–38). To the best of our knowledge, there are not previously published reviews on the use of MF in respiratory patients, and the trials available are very limited. COPD is an invalidating disease that primarily compromises both respiratory and motor functions either during the acute and the chronic phase. Data from the literature, confirm that pulmonary rehabilitation is the most used and effective intervention provided in order to treat the underlying symptoms of COPD, namely dyspnea and muscle depletion (39–41). An appropriate planning of the rehabilitation activities for COPD patients is a cornerstone in order to reduce hospital readmission rate, which is very high in this population (42,43).

Data gathered from the retrieved citations showed that MF are used mainly to enhance muscle function as highlighted in the studies by Bustamante and Colleagues (33,34). Muscle weakness of the quadriceps, is one of the most invalidating condition occurring in COPD patients, resulting in exercise limitation, and consequent reduced motor activity. One of the most interesting aspects emerging from this review is represented by the fact that MF seems to have a positive effect on increasing size of the quadricep fibers in COPD patients (34). Lower limbs muscular action, together with all the others motor abilities related to daily life activities, is a fundamental biomechanical component of the walking. Thus, a dedicated treatment addressed to improve muscle strength is perfectly in line with the COPD characteristics, and patients' needs. On the other hand, electrical muscle stimulation has been proven as a suitable tool for the prevention of muscle atrophy in different class of subjects including patients with COPD (44–49).

From the analyzed studies (Table 2) and in particular from the article by Sadlonova et al. (18) MF seems to produce a favorable response in patients with COPD. However, this response was mainly subjective and related to improvement of ventilation and mucociliary clearance as reported by the patients treated with the pulsatile electromagnetic fields in comparison to those in the placebo group. Nevertheless, the amount and density of mucus were not measured; mucus clearance was evaluated only on the basis of patients reported informations, limiting the level of evidence of the observations made. On the other side, the informations regarding quantitative outcomes, such as the spirometry parameters, could demonstrate an improvement of some indices (Tiffeneau, forced expiratory volume in 1 sec., maximal expiratory flow at 25%, maximal expiratory flow at 50%, peak expiratory flow), but it wasn't identified any statistically significant effect of the technique on lung function.

A relevant aspect of this technique is its safe profile: MF are well tolerated and painless. Unexpected or significant side effects have not been reported even in the case of repeated stimulations; the only absolute contraindication is the presence of metal objects where magnetic stimulation is applied (i.e., pacemaker) (50). From data analyzed in the present review, it was not clear whether MF could also have a direct effect on the airways (i.e., prevent the remodeling of the airways), or on the lung parenchyma (i.e., avoid the alveolar damage): further studies are needed to assess these hypotheses.

Due to the paucity of data on the topic, further experimental research should be encouraged to deeply investigate the effectiveness of MF on COPD respiratory symptoms, especially because it is well established that peripheral muscle function correlates with the severity of the disease: indeed, it is a relevant parameter influencing dyspnea, exercise capacity and it is taken into account in the evaluation of the BODE index (51,52). Depletion of the muscle function is related to utilization of health care resources (53). Moreover, from a clinical perspective, it's noteworthy that many patients with COPD may have an exercise capacity limited by muscle fatigability rather than dyspnea, even when the respiratory function is impaired (54). Basing on the data currently available, it was not possible to get detailed informations about the operating costs of magnetic stimulation for patients with COPD. However, in one study (33) the authors highlighted that the stimulating device used in their research had a high cost.

Limitations

The present review bears a major limitation: since the topic is very narrowed, we found only a very small number of citations. On the other hand, the additional searching in the grey literature (materials outside of the traditional academic publishing) did not return supplementary data; this confirmed the underestimation of the use of MF in COPD, and of the related lack of knowledge. Moreover, although our findings are based on the analysis of experimental studies, the very small number of patients included in these analyses make it impossible to extend the results reported here to the whole COPD population. Hence, the information discussed here should be considered with caution. However, in spite of the above listed limitations, we believe that the paucity of data could represent rather a positive encouragement for further and additional investigations to improve our knowledge on the application of MF in COPD, particularly in the regard of the respiratory issues.

Conclusions

We found that the use of MF is described in the literature for the treatment of muscular impairment (quadriceps), and respiratory symptoms in patients with COPD. To date very few investigations have been conducted to explore the effectiveness of magnetic stimulation in COPD; it seems that there is an increasing space for the use of MF as a therapeutic option in patients with COPD mainly to counteract muscular depletion. In fact, in the present review we found that most relevant studies were published in the field of muscular rehabilitation rather than that of respiratory system. This aspect remains to be clearly defined, and further studies are necessary to clarify the potential direct effect of magnetic stimulation on the airways and lungs. At the same time, basing on the available informations, it seems that MF represent a feasible, well tolerated, safe therapeutic option, for the treatment of motor-related COPD symptoms. Furthermore, it should be better investigated which groups of patients with COPD (and at which stage) can benefit most from magnetic stimulation treatment, and indicated more precisely the fields and modalities of applications of this therapy.

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Declaration of interest

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