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DISCOVERY SCIENTIFIC SOCIETY

Effect of inspiratory muscle training in pulmonary function and relief of dyspnea in patients with heart failure; systematic review

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ABSTRACT

Background: IMT has already been shown to benefit patients with HF; however, it is unclear which patients benefit most from this intervention and what kind of training is most effective. We aimed to review the impact of IMT on respiratory muscle strength, pulmonary function, functional ability, dyspnea, and Qol in HF patients. *Method:* This systematic review was planned and carried out using the PRISMA guidelines. MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Trials were searched databases. In addition, a thorough search of the references of earlier studies on the subject was carried out. To locate publications published between 2011 and 2024, the search terms "heart failure" and "breathing exercises" were used. *Result:* we included eight trials totaling 299 patients. Isolated IMT was performed in five trials and contrasted with control groups. Two of these studies included participants with inspiratory muscle weakness. Three trials involved four to six weeks of training during the intervention phase. Three experiments combined IMT with an additional intervention; two of these investigations combined aerobic training and neuromuscular electrical stimulation. One study utilized a load as high as 60% of MIP, while two used loads as high as 30% of inspiratory muscle strength. *Conclusion:* In patients with respiratory and muscular insufficiency, training loads larger than 60% and longer intervention durations increased inspiratory muscle strength, functional ability, and quality of life more after isolated IMT.

Keywords: Heart failure, inspiratory muscle training, fatigue, dyspnea

1. INTRODUCTION

Heart failure (HF) is a chronic, debilitating illness (Conley et al., 2015). The personal and social burden of HF is marked by incapacitating symptoms and readmission, despite notable advancements in medication management for patients (Smart et al., 2013). Inspiratory muscle atrophy, is common in patients with HF. Exertion and activity-related respiratory muscle weakness can result in exhaustion and dyspnea (Montemezzo et al., 2014). One of the main signs of HF is dyspnea (Kupper et al., 2016). According to a study done on HF patients, 69% of them experienced severe dyspnea (Perez-Moreno et al., 2014). According to Kupper et al., (2016), dyspnea is substantially linked to variables like advanced age, body mass index, chronic obstructive pulmonary disease (COPD), and inflammatory markers like interleukin-6 and 10. Dyspnea can make people with HF feel more exhausted by limiting their everyday activities (Tsai et al., 2013).

Another classic HF symptom is fatigue. According to Perez-Moreno et al., (2014), 59% of HF patients reported moderate to severe fatigue. Fatigue is a reflection of hypo-perfusion in the muscles and a sign of a lowered cardiac output, the severity of which is linked to symptoms of anemia, depression, and muscle dysfunction. According to Tsai et al., (2013), fatigue is also a reliable indicator of a higher risk of cardiac readmission and death in patients with HF. Clinical factors like age, anemia, poor sleep quality, decreased exercise capacity, dyspnea, and psychosocial distress can all be used to explain fatigue (Kessing et al., 2016). Hence, fatigue and dyspnea are complex conditions that can limit day-to-day functioning and self-care, ultimately lowering the HF patient's quality of life (QoL) (Wang et al., 2016). Given the changes in the skeletal muscles in HF, the question of how fatigue and dyspnea symptoms will respond to inspiratory muscle training (IMT) arises.

In the pathophysiology of dyspnea and fatigue, the inability of the respiratory muscles to consume oxygen exceeds central hemodynamic defects (Pozehl et al., 2008). It is unknown how physical aerobic exercise impacts patients with the current criteria of HF, despite the fact that it has repeatedly been demonstrated to increase effort capacity and Qol in patients with HF with reduced ejection fraction (Taylor et al., 2014). In patients with HF and a reduced ejection fraction, other physical therapies like IMT also enhance exercise capacity and QoL Smart et al., (2013); however, there is insufficient data to support their clinical utility and viability in HF (Karavidas et al., 2013). In this study, we sought to review the effects of IMT on respiratory muscle strength, pulmonary function, functional ability, Qol, and dyspnea in patients with HF.

2. METHOD

The PRISMA was followed in the planning and execution of this systematic review. The following databases were searched: MEDLINE, EMBASE, and the Cochrane Central Register of Controlled Trials. A manual search of the references of previously published research on the topic was also conducted. The search phrases "heart failure" and "breathing exercises" were used singly or in combination, along with a filter specifically for RCTs, in order to find articles published between 2011 and 2024. Only research that had been published in English was taken into account. In the treatment of patients with HF in both decompensation and outpatient care, the RCTs assessing the efficacy of IMT were contrasted with control groups, placebo, or alternative interventions. The following outcomes were taken into account: pulmonary function, dyspnea, respiratory muscle strength, fatigue, and functional capacity.

Two authors evaluated each of the identified papers' titles and abstracts in duplicate, independently. All abstracts that did not give enough details about the inclusion criteria were chosen and included based on the eligibility requirements in order to be evaluated in their entirety. Arguments were settled by consensus. We included 8 randomized controlled trials in this review (Figure 1). A standardized form that the authors themselves produced was used to extract the data and contained details about the participants, main findings, and objectives of the studies. Consensus was also used to settle disputes. The strength of the respiratory muscles was the key outcome. Dyspnea, QoL, lung function, and functional ability were secondary outcomes.

3. RESULT

We included 8 studies with a total of 299 patients (Table 1). Five studies Bosnak et al., (2011), Marco et al., (2013), Mello et al., (2012), Moreno et al., (2017), Hossein et al., (2020) conducted isolated IMT and compared it with control groups. Two of these investigations involved subjects with weakness in their inspiratory muscles (Marco et al., 2013; Mello et al., 2012). In terms of load, loads as high as

30% were employed in two studies (Marco et al., 2013; Mello et al., 2012). Three studies conducted training for a duration of four to six weeks during the intervention period (Bosnak et al., 2011; Marco et al., 2013; Mello et al., 2012). Bosnak et al., (2011) conducted an 8-week research, while Melo et al., (2012) and Moreno et al., (2017) conducted 12-week investigations. Three trials coupled IMT with another intervention; two of these studies used neuromuscular electrical stimulation Kawauchi et al., (2017) and aerobic training (Adamopoulos et al., 2014).

In terms of load, two research Palau et al., (2019), Kawauchi et al., (2017) employed loads as high as 30% of (inspiratory muscle strength) MIP, while one study Adamopoulos et al., (2014) used a load as high as 60% of MIP. The results of Hossein et al., (2020) show that patients with New York Heart Association (NYHA) classes II, III, and IV of HF can benefit from moderate-intensity IMT by improving symptoms, including fatigue and dyspnea. IMT is significantly related to an improvement in exercise capacity and Qol in patients with HF who have inadequate aerobic capacity, per a study by (Palau et al., 2019). The Orygen-Dual Valvew combined with a 4-week high-intensity intermittent muscle training regimen has been demonstrated to be a safe, practical, and effective means of addressing inspiratory muscle weakness and exhaustion (Marco et al., 2013) (Table 2).

Table 1 Characteristic of the included studies

Citation	Country	Population characteristic	Control group	Management group
Hossein et al., 2020	Iran	Individuals with HF resulting from dilated or ischemic cardiomyopathy, age greater than 18, left ventricular ejection fraction (LVEF) ≤40%, NYHA functional classes II, III, or IV, no changes in cardiac medication during the study or for the previous two months, and hemodynamic clinical.	42	42
Bosnak et al., 2011	Turkey	Clinically stable, LVEF below 40%, no change in medications over three months and NYHA Class II and III.	14	16
Adamopoulos et al., 2014	Belgium	LVEF ≤35%, age >18, and NYHA functional class II–III	22	21
Kawauchi et al., 2017	Brazil	NYHA functional class II or III and LVEF <40%	9	26
Marco et al., 2013	Spain	Any cause of CHF, a minimum age of 18 years, a clinically stable state, NYHA functional classes II–III, and no worsening of HF or modifications to cardiac medication in the three months prior to or throughout the research.	11	11
Mello et al., 2012	Brazil	LVEF less than 45%, NEHA class II, clinically stable and no change in medication in the last 3 months.	12	15
Moreno et al., 2017	Brazil	NEHA class II or III, LVEF of less than 50%	13	13
Palau et al., 2019	Spain	NYHA class II, LVEF > 50%, clinical stability determined by no hospital admissions within the previous three months, structural heart disease or diastolic dysfunction assessed by echocardiography.	17	15

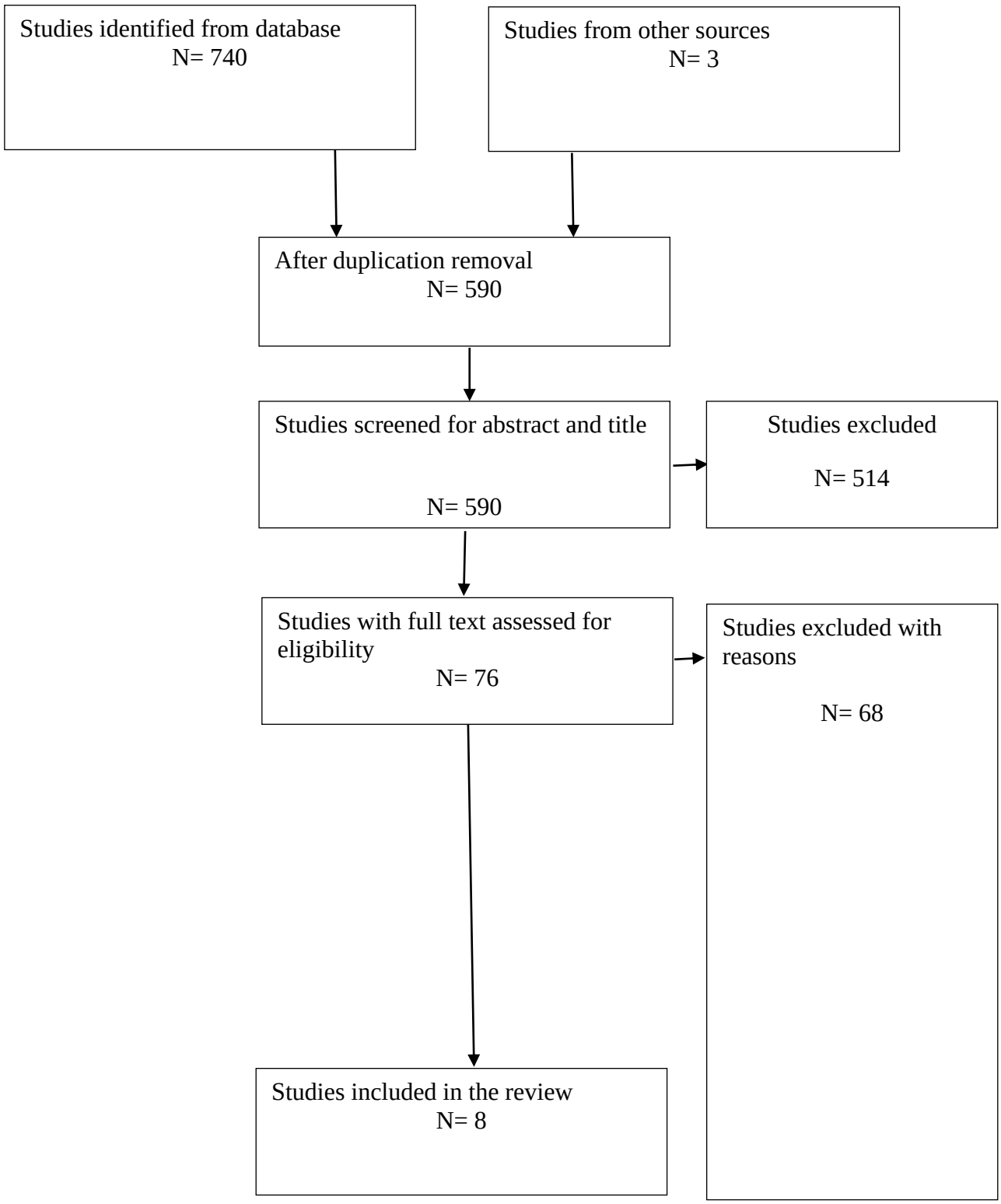

Figure 1 PRISMA consort chart

Table 2 Aim and main findings of the included studies

Citation	Aim	Main findings
Hossein et al., 2020	To assess how IMT affects HF patients' fatigue, dyspnea, and NYHA classification.	When comparing the IMT group to the sham group, the between-group analysis revealed a substantial improvement in dyspnea, fatigue, and the NYHA functional classification. Significant improvements in dyspnea, NYHA classification and fatigue, were observed in the IMT group, according to the analysis.
Bosnak et al., 2011	To look into how IMT affects HF patients' dyspnea, exhaustion, depression, pulmonary function, respiratory and peripheral muscle strength, and overall Qol.	The treatment group considerably outperformed the controls in terms of functional ability and balance, peripheral muscular strength, and dyspnea; QoL and fatigue also improved within the groups. The therapy group showed significant improvements in respiratory muscle strength, functional capacity, FVC%, PEF%, FEV1%, functional balance, depression, functional dyspnea, Qol, and fatigue. In the control group, there was a significant improvement in respiratory muscle strength, depression, FVC%, Qol, and fatigue.
Adamopoulos et al., 2014	To look into if IMT can help patients with persistent HF in an additional way.	The benefits of IMT were noticeably greater in QoL, dyspnea, and CRP. Peak oxygen uptake (VO2) and LVEF considerably improved in the interventional groups, although neither group saw any further benefits.
Kawauchi et al., 2017	To investigate the impact on muscle strength, functional ability, and Qol of IMT.	Improvements in QoL were similar across groups. Training regimens with low to high intensities increased walking distance, peripheral muscular strength, and inspiratory muscle strength. However, in HF patients, only moderate intensity resulted in improvements to expiratory muscular strength and NYHA functional class.
Marco et al., 2013	This study set out to assess the safety, feasibility, and efficacy of a 4-week IMT in CHF patients.	Both strength and endurance significantly improved in the IMT group of patients: inspiratory muscular strength rose 57.2% in the intervention group compared to 25.9% in the control group. In contrast to the control group, which saw a percentage change in endurance of 18.2%, the IMT group saw a 72.7% increase. The intervention had no negative effects.
Mello et al., 2012	To assess how IMT affects peripheral nerve sympathetic activity and cardiac autonomic regulation in CHF patients.	Peak oxygen uptake was dramatically raised by IMT, while QoL was improved, heart rate variability's HF components were increased, muscle sympathetic nerve activity was reduced, and peak ventilation carbon dioxide production

		ratio and slope were lowered. There were no noteworthy alterations noted in the group under controls.
Moreno et al., 2017	To ascertain how IMT affects patients with chronic HF's intercostal and forearm muscle hemoglobin oxygen saturation during respiratory exhaustion.	After eight weeks of involvement in the IMT group, there was a 78% increase in respiratory muscle strength. IMT mitigated the rise in blood lactate and decrease in oxygen saturation in the forearm and intercostal muscles during respiratory exhaustion. The Control group did not experience these modifications. Following eight weeks.
Palau et al., 2019	To assess if IMT enhances left ventricular diastolic function, biomarker profile, and Qol in HF patients as well as their ability to exercise for 12 and 24 weeks.	For IMT, the mean difference in peak exercise oxygen uptake at 12 weeks was 2.98 when compared to usual care, and this positive effect lasted for 6 months. At 12 weeks, QoL scores showed a significant increase. There were no other alterations discovered.

4. DISCUSSION

Our study's findings show that isolated IMT improved functional ability, inspiratory muscle strength, and Qol. These benefits were greater in studies involving patients with respiratory muscle weakness, training loads greater than 60%, and longer intervention durations. When used in conjunction with another intervention, the IMT did not show much improvement in respiratory muscle strength. As observed in this investigation, since respiratory muscle fatigue and dyspnea reported by these patients are linked to a poor functional capacity, the improvement in inspiratory muscle strength facilitated by isolated IMT may help in the application of the enhanced functional ability (Täger et al., 2015). Hossein et al., (2020) report that in patients with classes II, III, and IV HF, the IMT program significantly improved the patients' experience of fatigue, the degree of their daily dyspnea, and their NYHA classification.

In HF patients, IMT significantly improved their respiratory muscle strength, exertional dyspnea, exercise capacity, and peripheral blood flow during both exercise and rest (Chen et al., 2016). According to Laoutaris et al., (2016), the ability of patients with HF to perform tasks would be more affected by changes in the respiratory muscles than by changes in strength. Nearly half of the patients in the Hossein et al., (2020) study had COPD, and the majority of them had inspiratory muscle weakness. Diaphragm ischemia and reduced mechanical efficiency were caused by respiratory exhaustion or weakening of the inspiratory muscles. On the other hand, research showed that inspiratory muscular strength rose by 78% after 8 weeks of IMT (Moreno et al., 2017).

Cutrim et al., (2019) suggested that patients with COPD may benefit from low-intensity IMT (30%MIP) three times a week for 12 weeks in terms of improved cardiac autonomic regulation and exercise tolerance. According to a systematic review study, patients with respiratory muscle weakness benefit more from IMT in terms of their maximal and submaximal exercise capacities than patients with normal inspiratory muscle strength, even though both groups' exercise performance is improved (Montemezzo et al., 2014). According to a study by Palau et al., (2019) a low-intensity IMT program was linked to a considerable improvement in exercise capacity and Qol. It's interesting to note that IMT's positive impact on peak VO2 was about the same as that observed in patients with HF whose ejection fraction was lower (Laoutaris et al., 2004; Dall'Ago et al., 2006; Stein et al., 2009).

Chronic HF patients frequently have symptoms when they exert themselves (Kitzman et al., 2002). Exercise intolerance in these patients is caused by anomalies in the ventilatory, autonomic, and central hemodynamic responses to exercise, as well as skeletal muscle and vascular dysfunction (28). Thirty to fifty percent of patients with HF have weak inspiratory muscles Dall'Ago et al., (2006), Ribeiro et al., (2009), and this group's decreased ability to exercise is partly due to the exhausting nature of their inspiratory muscles. This shows that one key treatment target in chronic HF is the mechanisms—which are still poorly understood—that contribute to the reduction of respiratory fatigue. Vasoconstriction in resting limbs is mediated by the respiratory muscle metaboreflex, which is activated by respiratory resistive loading that causes exhaustion failure in healthy persons.

This activation is evaluated in the peroneal nerve, resulting in increased reflex sympathetic nerve discharge (Shei et al., 2022; Chiappa et al., 2008). When comparing the analysis of the IMT in conjunction with another intervention to the performance of the other intervention alone, the other assessed outcomes rose slightly. Adamopoulos et al., (2014) argues that because the patients included in the study did not have a major impairment, the lack of change in functional capacity with the addition of IMT to another intervention can be explained by the minor diaphragmatic muscle training added to aerobic exercise or baseline functional status.

5. CONCLUSION

In studies involving patients with respiratory muscular weakness, training loads more than 60%, and longer intervention durations, there was a greater increase in inspiratory muscle strength, functional capacity, and Qol following isolated IMT. In individuals with HF, IMT may be used as an adjuvant strategy, particularly if the patient does not respond well to traditional rehabilitation.

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Ethical approval

Not applicable.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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