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Systematic Review

THE BENEFITS OF INSPIRATORY MUSCLE TRAINING IN HEART FAILURE PATIENTS: A SYS-TEMATIC REVIEW

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Abstract

Background: Patients with heart failure (HF) have impaired function of respiratory system and frequently experience dyspnea. Inspiratory muscle training (IMT) offers an alternative way of exercise with a lot of benefits for HF patients.

Aim: The aim of this review was to summarize and to reveal the effects of IMT in HF patients.

Methods: Electronic searches were performed using Pubmed Database, Physiotherapy Evidence Database (PEDro) and Cochrane Library. Inclusion criteria were: RCTs, patients with HF, full text articles after 2010 and at least one intervention group with IMT. Methodological quality was assessed using the PEDro (Physiotherapy Evidence Database) scale.

Results: Nineteen articles met the inclusion criteria and were included in this review. In most studies training protocols involved 3 to 7 sessions per week with intensity \leq 30-60% of maximal inspiratory pressure (MIP), for a total duration of 4-12 weeks. Respiratory muscle strength improved in 11/12 studies, peripheral muscle strength in 4/5 studies, exercise capacity (peak VO₂, VE/VCO₂ slope) in 4/10, pulmonary function (FEV₁, FEV₁/FVC, FVC) in 0/5, functional capacity (6MWT) in 6/8, echocardiography parameters in 1/6, quality of life and dyspnea in 9/16. Control groups followed sham IMT, usual care, no intervention, intervention without exercise, or aerobic training, which could explain in some cases the conflicting results.

Conclusions: IMT is beneficial for HF patients and should be included as a complementary method in cardiac rehabilitation programs. The optimal characteristics of IMT as well as the benefits when combined with common forms of exercise need further research.

Keywords: Inspiratory muscle training, respiratory muscle training, inspiratory resistance training, breathing exercise, heart failure.

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INTRODUCTION

Chronic heart failure (CHF) is a complex disease characterized by a wide range of symptoms (e.g. dyspnea, muscle fatigue) and signs (e.g. pulmonary dysfunction, abnormal breathing patterns).^{1,2} Several skeletal muscle and respiratory abnormalities including impaired resting lung function, peripheral muscle microcirculation and inefficient ventilation have been identified in CHF patients that probably play an important role in the pathophysiology of exercise intolerance.³⁻⁵ Also, CHF patients demonstrate increased respiratory drive at rest and abnormal breathing pattern during exercise which is associated with disease severity.⁶ Moreover, patients with CHF present impaired inspiratory muscle strength and endurance, an additional factor which is associated with limited exercise and poor prognosis.⁷ There is evidence of benefits from IMT applied in CHF patients, including improvement of respiratory muscle strength, functional capacity, ventilation, guality of life and decreased dyspnea.⁸⁻¹²

The aim of this review is to summarize and shed light on the effects of IMT in CHF patients, as well as to provide more reliable estimates regarding the usefulness of respiratory training as a complimentary method in the HF rehabilitation programs.

METHODOLOGY

Data sources

The literature research was performed in the following electronic databases: Pubmed, Cochrane library and Physiotherapy Evidence Database (Pedro). The keywords used in the search were: inspiratory muscle training, IMT, respiratory muscle training, respiratory exercise, inspiratory resistance training, breathing exercise, heart failure, CHF. These terms were appropriately combined using the booleans OR and AND. For example, the search strategy in Pubmed database was as follows: (Inspiratory muscle training OR IMT OR Respiratory muscle training OR Respiratory training OR Respiratory exercise OR Inspiratory resistance training OR Breathing exercise) AND (Heart failure OR CHF). The search was restricted by the following criteria: Clinical Trials, Full Text studies, humans and English language, using appropriate filters.

We included studies with or without combined exercise programs. Inclusion criteria were the following: 1) RCTs, 2) HF patients, 3) full text articles, 4) articles published after 2010. Exclusion criteria were: 1) animal studies, 2) languages other than English.

Our data presented patient characteristics (number of patients included, age, gender, diagnosis and disease severity), intervention (type, duration, frequency, resting period) and outcomes related to respiratory muscle strength, pulmonary function, exercise capacity, peripheral muscle function, functional capacity, quality of life and dyspnea.

Methodological quality

The methodological quality of the studies was evaluated by the PEDro scale. The Pedro scale is based on 11 items to assess scientific rigor related to eligibility criteria, allocation, baseline between-group comparability, blindness of subjects, therapists, and assessors, follow-up, statistical analysis, and results reporting¹³. Based on the total score, studies were categorized as high-(> 5), moderate- (4-5), or low- (< 4) quality.

RESULTS

Study selection

The initial search led to retrieval of 1798 articles. After 1350 duplicates were removed, 450 records were screened at abstract level. The full text of 31 studies was assessed for eligibility. Of those 31 studies, 12 were excluded being published before 2010. Finally, 19 RCTs were included in the present review.¹⁴⁻³² The PRISMA flow diagram is presented in figure 1.

Methodological quality

The Pedro score for the included studies is presented in Table 1. The score ranged from 5 to 8 (that is, moderate to high quality). The allocation of subjects was concealed in 6 studies.^{14,20,21,24,27,31} Furthermore, all the studies provided baseline data ensuring between-group comparability. All the studies met the follow up criteria as described by Pedro scale. Ten of the studies were of high methodological quality (PEDro score>5)^{14-17,20,23,26,27,31} and nine studies were of moderate quality (PEDro score =5).^{18,19,22,24,25,28,29,30,32} The level of evidence could be considered as moderate to strong.

Participants

The characteristics of the patients included in this systematic review are presented in Table 2. We included data that were relevant for at least one of the main outcomes of interest. Data from 726 patients were analyzed. Disease severity was categorized by the NYHA classification. Two studies had CHF patients with preserved ejection fraction.^{26, 27} The remaining 17 studies had CHF patients with reduced ejection fraction. One study investigated stroke patients with stable CHF²³ and another study included patients with implanted left ventricular assist device.¹⁶ Inspiratory muscle weakness was identified in some of the patients included in the study (MIP<70% of the predicted value).^{14, 19, 21, 23}

Interventions

The characteristics of the interventions are shown in Table 2. IMT duration ranged, in most studies, from 4 to 12 weeks.^{14-24,26,28} One study lasted 4 months.²⁵ Two studies started with 10-12 weeks IMT, followed by 10-12 weeks usual care (crossover studies).^{29,31} Three studies used follow up evaluation: one study at 5 months³⁰ and two studies at 6 months.^{27,32} Concerning the load, 9 studies used loads > 30% to 60% of maximal inspiratory pressure (MIP) or sustained MIP (SMIP).15-18,20-23,25 One study used training loads which allowed the performance of 10 consecutive maximal repetitions (10RM), so the training intensity was 100% of their 10 RM.¹⁴ Five studies used load \leq 30% of MIP.^{19, 21, 24, 26,} ²⁷ Frequency of training ranged from 3 to 7 times per week with duration of each session, mostly, up to 30 minutes, with 1 or 2 sessions per day and with a common respiratory rate of 15-20 breaths/min. In relation to the training methods employed, IMT was performed using an inspiratory muscle trainer with training loads adjusted to the inspiratory pressure, 14-27 or using a deviceguided slow breathing via the introduction of low and high-frequency tones to entrain exhalation and inhalation, 28,29,31,32 or using deep and slow diaphragm breathing training according to voice-quided directions.³⁰

Concerning the control groups, patients performed IMT with low or no respiratory load, ^{14,17,19-21} aerobic training, ^{15,16} combined training (aerobic with IMT or with strength exercises),^{18,22} usual care treatment,^{26,27,29,31} intervention without exercise^{23,28,30} and no intervention.^{24,25}

Functional assessments

Respiratory muscle strength

Five studies evaluated the effect of combined exercise/IMT vs. control group on respiratory muscle strength;^{15,16,18,22,24} MIP improved in two studies,^{22,24} SMIP^{15,18} improved also in two studies, maximal expiratory pressure (MEP) improved in one study,²⁴ whereas nonsignificant differences were observed in MIP in three studies^{15,16,18} and in SMIP in one study.¹⁶ Seven studies^{14,17,19,21,23,25,26} examined IMT alone with no other form of exercise training; intervention groups demonstrated significant improvement in MIP (all studies) and in MEP (two studies),^{14,17} compared to control groups, while no significant differences were found in MEP in one study.²³

Peripheral muscle strength

Five studies assessed peripheral muscle strength.^{14,15,17,22,24} Three studies^{15,22,24} used combined exercise/IMT vs. control group and evaluated lower limb muscle strength (quadriceps femoris). The results revealed significantly higher muscle strength and endurance in the treatment groups compared with the control groups. The remaining two studies^{14,17} examined IMT alone with no other form of exercise training, with conflicting results. One study¹⁴ evaluated upper limb muscle strength (handgrip strength) and revealed no significant differences between groups, while the other one¹⁷ found greater improvement of peripheral muscle strength and functional balance in the treatment group compared to controls.

Pulmonary function

Five studies^{16-18,23,24} evaluated the effect of IMT on pulmonary function, mostly employing: forced expiratory volume in 1 s (FEV₁), forced vital capacity (FVC), FEV₁/FVC; no significant differences were observed between the intervention and control groups.

Exercise capacity

Six studies assessed the effects of combined exercise/IMT vs. control group using cardiopulmonary exercise testing (CPX).^{15,16,18,22,26,27} Variables mostly employed were peak oxygen uptake (peak VO₂), ventilation/carbon dioxide slope, VE/VCO₂ slope and VE. Four of these studies^{15,16,18,22} revealed no significant differences in most CPX parameters between the intervention and control groups, whereas the other two studies^{26,27} found significant improvement of CPX parameters in the trained patients.

Five studies investigated the effects of IMT alone with no other form of exercise training vs. control group^{19,21,25,27,32} on cardiopulmonary function. Two studies revealed no significant differences between the intervention and control groups in most CPX parameters.^{19,32} In the remaining three studies, trained patients presented significantly improved CPX parameters compared to controls.^{21,25,27}

Echocardiographic parameters

Four studies evaluated the effects of combined exercise/IMT vs. control group on echocardiographic parameters and reported no significant differences between the intervention and control groups.^{15,18,26,27} Three studies^{27,31,32} evaluated the effects of IMT alone with conflicting results; one study³¹ reported significant improvement in most echocardiographic parameters, while the other two studies^{27,32} reported no significant changes in echocardiographic parameters.

Functional capacity

Four studies^{16,24,26,27} assessed the effect of combined exercise/IMT vs. control group on functional capacity using the six minute walk test (6MWT). Conflicting results emerged. Three studies^{24,26,27} found that the distance covered during the 6MWT significantly increased in the treatment groups compared to control groups, whereas one study¹⁶ found no significant differences between groups. Five studies^{17,27,30-32} used IMT alone and all but one³⁰ showed significant improvement in the treatment groups compared to control groups.

Quality of life and dyspnea

Seven studies^{15,16,18,22,24,26,27} evaluated the effect of combined exercise/IMT vs. control group on quality of life (Qol) and dyspnea using several assessment methods. Three studies found no significant changes in Qol^{16,22,24} and dyspnea¹⁶ between the intervention and control groups, whereas four studies reported significant improvement in Qol^{15,18,26,27} and dyspnea^{15,18} in the intervention compared to control groups. Ten studies used IMT alone^{14,17,19-21,25,27-30} with conflicting results; four studies found no significant differences between the intervention and control groups regarding Qol^{14,17,29} and dyspnea^{14,28,30} while in six studies the intervention groups showed significant improvement in Qol^{19,21,25,27} and dyspnea^{17,19,20} compared to control groups.

Functional classification

Three studies^{15,18,24} assessed the effect of combined exercise/IMT vs. control group on functional status using the New York Heart Association (NYHA) classification and reported no significant differences between the intervention and control groups. Two studies^{20,28} used IMT alone with conflicting results; NYHA class improved in the training group compared to the control group in one study,²⁰ while the other one²⁸ did not show significant differences between groups.

DISCUSSION

This systematic review indicates that IMT, isolated or combined with other forms of exercise training, improves respiratory and peripheral muscle strength, whereas it seems to have no effect on pulmonary function. Furthermore, the included studies demonstrate conflicting results after IMT application regarding the other parameters of interest: exercise and functional capacity, echocardiographic parameters, quality of life and dyspnea. The results were varying among the studies likely because of the different loads (adjusted for MIP/SMIP), the method employed, i.e., *threshold IMT, device-guided breathing and diaphragmatic exercises*, the frequency and duration of intervention as well as the small sample size of the studies. The best mode and training method of IMT is not clear.

All the studies which performed IMT based on SMIP revealed non-significant differences in MIP; utilization of SMIP adjusted load seems to improve the respiratory muscle endurance and not the MIP.^{15,16,18} This could possibly explain, at least partly, the conflicting results. Analysis of the studies showed that IMT at a low percentage load (\leq 15% of MIP)^{14,17,19} was not enough for the control groups to reach the same improvements as the intervention groups which used training loads \geq 30% of MIP. Another study came to the same conclusion, comparing the effect of low intensity training (15% of MIP) and moderate intensity training (30% of MIP); it was shown that only the moderate intensity exercise training improved MEP and NYHA functional classification.²⁴

IMT when combined with a specific program of lower limb muscle resistance training improved peripheral muscle strength.^{15,22,24} IMT when performed without other form of intervention improved also peripheral muscle strength; although this result is a clear indication of an autonomous beneficial effect of this type of exercise training (i.e. IMT) on peripheral muscle strength,¹⁷ there is a need for further research for its final documentation. In another study which used IMT alone, upper limb muscle strength (handgrip strength) did not correlate with MIP.¹⁴

All studies, regardless of using IMT alone or combined with other form exercise training, presented no differences in pulmonary function in between-group comparisons.^{16,17,18,23,24} This result may be due to the relatively good functional status of the lungs at baseline or because of an inappropriate training method, unable to improve the spirometric parameters (FEV₁, FEV₁/FVC, FVC). NYHA status improved in all studies but one;²⁸ the duration and respiratory rate of the device-guided breathing exercise technique could probably account for the result.

Although studies revealed within group improvements in exercise capacity, functional capacity, quality of life and dyspnea after IMT, results were varied in terms of between-group comparisons; in several studies no differences were noted between the intervention and control groups regarding peak VO₂ and VE/VCO₂ slope,^{15,16,18,19,22,32} 6MWT,^{16,30} as well as quality of life and dyspnea;^{14,16,22,24,28-30} this may be due to the fact that in some cases not only the intervention but the control groups also incorporated aerobic exercise in their training programs or they had almost the same training characteristics (duration, rest, sham-IMT). Furthermore, echocardiographic parameters^{15,18,26,27,32} were not improved in almost all studies.

Patients with preserved ejection fraction^{26,27} showed remarkable improvements in functional capacity, exercise capacity and quality of life, as patients with reduced ejection fraction. Follow up evaluations^{27,30,32} also, revealed that IMT beneficial effects are maintained in most outcomes of interest.

Different training methods may lead to different results: some studies utilize a Threshold IMT breathing trainer for continuously providing a specific resistance (e.g. 30% of MIP) which is controlled, i.e. determined by the training supervisor; in contrast, other studies use other exercise techniques that focus on slow and deep inhalations according to recorded instructions.

Heart and lungs are interconnected, being parts of the system that supplies oxygen to the body organs and tissues. However, peripheral muscle dysfunction and inspiratory muscle weakness seems to be involved in the underlying mechanisms for fatigue, dyspnea and exercise intolerance in patients with HF. At rest and during exercise HF patients hyperventilate, causing structural and biochemical alterations in diaphragmatic muscle.³³ The effect of IMT on respiratory system, functional status and quality of life in patients with HF has been studied by many researchers. Potential mechanisms, underlying the effects of respiratory training, include increased ventilatory efficiency, lower oscillatory ventilation during incremental exercise, improved recovery oxygen uptake kinetics, as well as reduced sympathetic nervous activity.^{8,21} The use of IMT, also, attenuates the mechanisms involved in respiratory muscle metaboreflex in CHF patients, improving blood flow in peripheral muscles during inspiratory loading, in resting and exercising limbs.^{19,34}

In a previous review by Lin et al,³⁵ which included studies with isolated or combined IMT, it was shown that IMT significantly improves respiratory muscle strength and functional capacity, whereas, the effect of IMT on quality of life was inconsistent; this could be due to the different evaluation questionnaires being used. The improvement in inspiratory muscle strength could be translated to an improvement in functional capacity as CHF patients demonstrate low functional capacity due to respiratory fatigue and dyspnea.^{8,36} In another review by Neto et al,³⁷ combined exercise along with IMT offered additive benefits in quality of life compared with conventional aerobic training alone although, no extra benefits were established regarding the exercise capacity. This improvement in quality of life may be related to the benefits of IMT in cardiovascular and respiratory response as well as in the reduction of dyspnea.

Limitations

There were several limitations in the articles we reviewed. Initially, the sample size in all studies was small. There is a need for more randomized controlled trials in future with well-defined protocols and larger samples. Articles with device-guided paced breathing in HF patients were limited, as well as studies in patients with preserved ejection fraction and follow up evaluations. In addition, the improvement identified in the control groups in respiratory muscle strength probably occurred because they used IMT at a low percentage of MIP as sham therapy. It would be better if all the studies were designed without any training load in their control groups.

CONCLUSIONS

There is substantial evidence that IMT in patients with HF increases respiratory and peripheral muscle strength and seems to be beneficial regarding functional capacity, exercise capacity, quality of life and dyspnea. IMT should be part of a cardiac rehabilitation program as a complementary method, considering its safety and the demonstrated positive effects. The optimal characteristics of IMT as well as benefits when combined with common forms of exercise need further research. Also, more follow up evaluations are needed to explore the long term effects of respiratory training in patients with heart failure.

Conflict

of

interest:

Authors declare that there is no conflict of interest.

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ANNEX

Figure 1. Flow diagram of search strategy.



	Random allocatio n	Con ceal ed allo cati on	Baseline compara bility	Blinded subjects	Blinded therapist s	Blinded assessors	Follow- up	Intenti on-to- treat	Between -group analysis	Point estimate s and variabilit y	Total score
Bosnak- Guclu et al, ¹⁷ 2011	1		V	4		~	4		1	1	7
Ekman et al, ²⁸ 2011	٧		٧				V		1	V	5
Laoutaris et al, ¹⁶ 2011	1		V			~	4		~	~	6
Mello et al, ²¹ 2012		٧	4		4	4	4			4	6
Laoutaris et al, ¹⁵ 2013	4		٦			1	4		7	1	6
Marco et al, ¹⁴ 2013		4	V	٦	V	~	V		~	\checkmark	8
Palau et al, ²⁶ 2014	4		4			4	4		1	\checkmark	6
Adamopou los et al, ¹⁸ 2014	4		V				4		7	1	5
Drozdz et al, ²⁹ 2015	V		V				4		~	\checkmark	5
Seo et al, ³⁰ 2015	٦		V				V		1	\checkmark	5
Chen et al, ²³ 2016	٦		٧			V	V		1	V	6
Kawauchi et al, ²⁴ 2017		4	V				4		~	~	5
Kawecka et al, ³¹ 2017		V	V		V		V		~	\checkmark	6
Moreno et al, ¹⁹ 2017	V		V				V		~	\checkmark	5
Palau et al, ²⁷ 2020		V	V			~	V	~	1	\checkmark	7
Hornikx et al, ²² 2020	V		V				V		1	\checkmark	5
Hossein Pour et al, ²⁰ 2019		4	4	1	4	~	4		~	~	8
Lachowska et al, ³² 2019	1		1				1		1	1	5

TABLE 1. Methodological quality of the studies included in the systemic review (Pedro scores)

Antunes-	4	1		1	1	1	5
Correra et							
al, ²⁵ 2020							

TABLE 2. Intervention characteristics, parameters, outcomes and main results of the studies which included in this review

Study	Sample of inter- vention/ control group	Interve by gro Con- trol grou p	entions up/side Experi- mental group	IMT param- eters	Study Mea Functiona Periph- eral muscle strength	asurements assessments Respiratory muscle strength	Exercise and func- tional ca- pacity	Pulmo- nary func- tion	Quality of life, dysp- nea & echo- cardiog- raphy pa- rameters
Marco et al, ¹⁴ 2013	22 CHF Exp= 11 Age: 68.5±8.88 yr Con= 11 Age: 70.1±10.7 5 years NYHA: II- III	Sham -IMT	IMT	4 wk IMT F: 2x/d, 7d/wk 5 set/10 rep R: 1-2 min RR:15-20 breaths/min Exp: I: 10 consec- utive max in- spirations (10RM)- 100% of their 10RM Con: I: 10 cmH ₂ O & ↑ 2.5 cmH ₂ O/wk	Exp: \leftrightarrow in upper limb muscles Con: \leftrightarrow in upper limb muscles Between groups: \leftrightarrow in up- per limb muscles	Exp: ↑MIP, ↑MEP Con: ↔ MIP, MEP Between groups: Exp ↑MIP, ↑MEP Vs Con			Exp: ↓dysp- nea ↔ Qol Con: ↔ Qol, dyspnea Between groups ↔ Qol, dysp- nea

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et al. ¹⁵ 2013 Exp = 13 Age: 57.1211 yr Com 14 Age: 58.6~8 yr INT (AT, RT) Age: 57.1211 yr P. 3X/wk MT TOMT AT: bike ex- ercise 70- 80% of max HR TSMIP VO ₂ , fex- ercise time TRMIP N/VHA: VO2 fex- ercise time TSMIP N/VHA: VVEDD, N/VHA, dypn- ecise time, f.2P, VFACO2 N/VHA: VVEDD, N/VHA, dypn- ecise Leoutoris Equation 2011 15 CHF AT IMT/X TSMIP TOW TSMIP Exp fNIP, TSMIP Exp fNIP, VFACO2 Exp fNIP, VFACO2 Exp fNIP, VFACO2 Exp fNIP, VFACO2 Exp fNIP, VFAC0 Exp fNI	Laoutaris	27 CHE	AT	ARIS	12 wk	Exp.	Exp [.] ↑MIP	Exp: ↑peak		Exp: ↑Ool
2013 Exp=13 Age: 57.1+11 yr IMT, Con= 14 Age: 58.6+8 yr IMT, Sim ke exp con= 14 Age: 10.011 IMT, Sim ke exp con= 16 Age: 11.011 IMT, Sim ke exp con= 17 Age: 11.011 IMT, Sim ke ex	et al ¹⁵	27 6111		(ΔT/RT/	E. 3x/wk	±∩MT	±xp: 1111 , ↑SMID	$VO_{2} \uparrow ev_{-}$		LNVHA
	et al,	Exp= 13			T. 3X/ WK		TSIVIIF			
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		57.1±11 yr				1RM	↔ SMIP			↑LVESD
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Con = 14			80% of max	_		↓VE/VCO ₂		\leftrightarrow dyspnea
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NYHA: II/IIINYHA: II/IIIApp and 35 min for Con groupDeak, min for Con groupExp 1MP, meaCon: tpeak vCo, tex- ercise slope, RER $\leftrightarrow Ol,$ twend ercise groups: slope, RER $\leftrightarrow Ol,$ twend ercise groups: groups: slope, RER $\leftrightarrow Ol,$ twend ercise groups: $\leftrightarrow Ol,$ twend ercise groups: trans, 1CP, 1T, $\leftrightarrow VE,$ groups: slope, RER $\leftrightarrow Ol,$ twend ercise groups: $\leftrightarrow Ol,$ twend ercise groups: $\leftrightarrow Ol,$ twend ercise groups: $\leftrightarrow Ol,$ twend ercise groups: $\leftrightarrow Ol,$ twend ercise groups: $\leftarrow Ol,$ twend ercise groups: $\leftarrow Ol,$ twend ercise groups: $\leftarrow Ol,$ twend ercise groups: $\leftarrow Ol,$ twend ercise groups: $\leftarrow Ol,$ twend ercise groups: $\leftarrow Ol,$ twend ercise twend twe		58.6±8 yr			1: 30 min for	\leftrightarrow QMT	groups.	\leftrightarrow RER, VE,		(%),↑LVESD
					Exp and 45	peak,	Exp ↑SMIP,	Com trook		\leftrightarrow Qol,
					min for Con	1RM,	↔ MIP Vs Con			LVEDD,
Laoutaris et al.** Age: Age: 41.8+14.6 yrATIMT/AT10 wk Both groups: Exp: 1:50% of 12000000000000000000000000000000000000		11/111			group			VO ₂ , ∣ex-		NYHA, dvsp-
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$ \left \begin{array}{cccccccccccccccccccccccccccccccccccc$					RT:			$\uparrow VT, \leftrightarrow VE,$		Between
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$					I: 50% of	Exp		VE/VCO ₂		aroups.
Laoutaris et al.16 201115 CHF Age: 37.2±17.7 yrAT NT N Between after al.16 Age: 41.8±14.6 yrMIT/AT AT Age: Age: 41.8±14.6 yrMIT/AT AT Age: A					1RM	↑QMT		slope, RER		g. c apo.
Laoutaris et al, ⁶ 201115 CHF Age: 37.2±17.7 yrATIMT/AT10 wk Both groups Cises T: 15 min R: 2 minExp: 1/MIP, Con Con Exp 15.ver- Cise time, Con Con Con Con Con Con ConExp: 1/Deak Con Con Con Con Con Con Con Con Con Con Con Con ConExp: 1/Deak Between groups: Con Con Con Con Con Con Con Con VE/D, UVEDD, Con: Con: <+ MIP, SMIP SMIP SMIP SMIP SMIP SMIP SMIP SMIP SMIP SMIP SMIP SMIP SMIP SMIP SMIP SConExp: 1/Deak Exp: 1/Deak Exp: 1/Deak Exp: 1/Deak Exp: 1/DC Con: <+ MIP, SMIP SMIP SMIP SMIP VS ConExp: 1/Deak Exp:					3set/10-12	peak,				Exp ↑Qol,
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Laoutaris et al.1615 CHF Exp = 10ATIMT/AT10 wk Both groups 					SMIP			peak VO ₂		
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et al, 16 Both groups walked every day for 30- 45 min VO_2, TVO_2 at ventila- VO_2, TVO_2 Uug, \leftrightarrow VO_2, TVO_2 $\omega dyspnea$ at ventila- $VO_3, FEV_1(\%),$ $VO_4, FEV_1(\%),$ VO_2, TVO_2 $\omega dyspnea$ $Uug, \leftrightarrowVO_3, TVC_4Age:37.2±17.7yr45 minExp:Bike ortreadmillBetweengroups:Con: \leftrightarrow NIP,VE/VCO_2slopeCon: \leftrightarrow Qol,dyspnea,Age:41.8±14.6yr12-14 ofBorg scaleT: 45 minF: 3-5x/wkBetweenT: 45 minF: 3-5x/wkExp \leftrightarrow MIP,SMIP Vs ConOon: \leftrightarrow ICVE, RER,(\%), FEV_1/FVCBetweengroups: \leftrightarrowdyspnea,IMT:I: 60% ofSMIPIMT:I: 60% ofSMIPIMT:F: 2-3x/wkIMT:TTF: 2-3x/wkImticeToryFEV_1/FVCToryFEV_1/FVCTory$	Laoutaris	15 CHF	AT	IMT/AT	10 wk		Exp: ↑MIP.	Exp: ↑peak	Exp: ↑IC	Exp: ↑Ool.
2011Exp = 10Walked every day for 30- 45 minCon: \leftrightarrow MIP, SMIPToryFVC (%), toryCon: \leftrightarrow Qol, dyspneaAge: 37.2±17.7 yrA5 minExp: Bike or treadmillBetween groups:Con: \leftrightarrow MIP, SMIPCon: \leftrightarrow IC VE/VCO_2 Between (%), FEV1 (%), dyspnea,Age: 41.8±14.6 yr12-14 of F: 3-5x/wkI: moderate F: 3-5x/wkExp \leftrightarrow MIP, SMIP Vs ConCon: \leftrightarrow Groups: \leftrightarrow (%), FEV1Between (%), FEV1 QolIII.8±14.6 yr12-14 of F: 3-5x/wkIII.8±14.6 F: 3-5x/wkCon: \leftrightarrow Groups: \leftrightarrow peak VO2, I C lung, VE/VCO2FEV1/FVC VC (%), FEV1 PickerDetween groups: \leftrightarrow dyspnea, QolIIII.8±14.6 yrIII.8±14.6 F: 3-5x/wkIIII.8±14.6 F: 3-5x/wkExp \leftrightarrow MIP, SMIP Vs ConExp \leftrightarrow VE, RER, Between Con: \leftrightarrow groups: \leftrightarrow groups: \leftrightarrow peak VO2, I C lung, VE/VCO2Point III.8±14.6 FEV1/FVCIIII.8±14.6 yrIIII.8±14.6 F: 3-5x/wkIIII.8±14.6 F: 3-5x/wkFILE III.8±14.6 FILE III.8±14.6 FILE III.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 FILE III.8±14.6 FILE III.8±14.6 YrIIII.8±14.6 FILE III.8±14.6 FILE III.8±14.6 FILE III.8±14.6 FILE III.8±14.6 FILE III.8±14.	et al ¹⁶			,	Both arouns		1 ↑SMIP	$VO_2 \uparrow VO_2$	luna ↔	↔ dyspnea
Age: 37.2 ± 17.7 yrAge: 37.2 ± 17.7 	2011	Exp= 10			walked every			at ventila-	EVC (%)	() ayophea
Age: 37.2 ± 17.7 yrAge: $Exp:$ Bike or treadmill I: moderateSMIPtoty threshold, $1 \vee E \vee I \vee C \rangle$ slopeFEV1(%), dyspneadyspneaAge: 41.8 ± 14.6 yrI: moderate $12-14$ of Borg scale T: 45 min F: $3-5x/wk$ Between $12-14$ of Borg scale T: 45 min F: $3-5x/wk$ Between $2 \vee E \vee I \vee E \vee E$	2011				day for 20		Con: \leftrightarrow MIP,	ton	F V C (70),	Con: \leftrightarrow Qol,
37.2 ± 17.7 yrExp: Bike or treadmill 12-14 of yrBetween groups:https://ice.or fold/fileBetween groups:FEV1/FVCBetween groups:Age: 41.8±14.6 yr12-14 of Borg scale T: 45 min F: 3-5x/wk12-14 of Borg scale T: 45 min F: 3-5x/wkExp \leftrightarrow MIP, SMIP Vs ConSMIP Vs Con \leftrightarrow VE, RER, (%), exercise $(\%)$, FEV1 dyspnea, QolMIP peak VO2, SMIPIMT: I: 60% of SMIPIMT: I: 60% of SMIPIMT: F: 2-3x/wkIMTIMT: F: 2-3x/wkIMT		Age:					SMIP	tory	$FEV_1(70),$	dyspnea
yrExp:Between $16MWI, \ VE/VCO_2$ Con: \leftrightarrow ICBetweenCon= 5Bike or treadmillgroups: $30pe$ lung, FVCgroups: \leftrightarrow Age:I: moderateSMIPSMIP, SMIP Vs Con \leftrightarrow VE, RER, $(\%),$ Qol 41.8 ± 14.6 12-14 ofBorg scaletimeBetween ime yrBorg scaleT: 45 minF: 3-5x/wkCon: \leftrightarrow groups: \leftrightarrow groups: \leftrightarrow IMT:I: 60% ofSMIPSlope, VO2,IC lung,Ii: 60% ofSMIPslope, VO2,FEV1(%),iiSMIPF: 2-3x/wktorytorytoryii		37.2±17.7			45 11111				FEV1/FVC	J 1
Con= 5Bike or treadmill 12-14 ofgroups: $\downarrow VE/VCO_2$ Cont. $\leftrightarrow IC$ slopegroups: \leftrightarrow dyspnea, QolAge: 41.8±14.6 yr12-14 ofExp \leftrightarrow MIP, SMIP Vs Con $\leftrightarrow VE, RER, (\%),$ exerciseQolT: 45 min F: 3-5x/wkT: 45 min F: 3-5x/wkExp $\leftrightarrow VE, RER,$ peak VO2,ILung, FVC ($\%$), FEV1/FVCQolIMT: I: 60% of SMIPIMT: F: 2-3x/wkIMT: F: 2-3x/wkIMT: F: 2-3x/wkFEV1/FVC F: 2-3x/wkFEV1/FVC Fith of the total distribution		yr			Exp:		Between	16MWI,	Con: 🛶 IC	Between
Con= 5Image of treadmillSupportSup					Eiko or		groups:	↓VE/VCO ₂		groups: ↔
Age: 41.8±14.6 yrI: moderate 12-14 of Borg scale T: 45 min F: 3-5x/wkExp \leftrightarrow MIP, SMIP Vs Con(%), FEV1 QolQolCon: \leftrightarrow peak VO2, IC lung, VE/VCO2 Slope, VO2 FVC (%), slope, VO2 FEV1/FVCBetween FEV1/FVCImage: Qol		Con= 5						slope		dyspnea
Age: 41.8±14.6 yrI: moderate 12-14 of Borg scale T: 45 min F: 3-5x/wkSMIP Vs Con↔ VE, RER, exercise time(%), exercise timeGOI00112-14 of Borg scale T: 45 min F: 3-5x/wk12-14 of Borg scale T: 45 min F: 3-5x/wkSMIP Vs Conexercise exercise peak VO2, VE/VCO2 FVC (%), slope, VO2 FEV1/FVCGOI					treadmill		$Exp \leftrightarrow MIP$,	\ <i>/</i> = ===	(%), FEV ₁	
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yrBorg scale T: 45 min F: 3-5x/wktime BetweenIMT: $1: 60\% \text{ of}$ $5MIP$ IMTCon: \leftrightarrow peak VO2, $1C lung,SMIPF: 2-3x/wkSMIPF: 2-3x/wkVE/VC021000000000000000000000000000000000000$		41.8±14.6			12-14 of			exercise	FEV ₁ /FVC	
T: 45 min F: $3-5x/wk$ Con: \leftrightarrow groups: \leftrightarrow peak VO2, IC lung,Between groups: \leftrightarrow peak VO2, IC lung,IMT: I: 60% of SMIP F: $2-3x/wk$ VE/VCO2 Stope, VO2 toryFVC (%), FEV1(%), at ventila- tory		yr			Borg scale			time	Det	
F: $3-5x/wk$ Con: \leftrightarrow peak VO2, IC lung, VE/VCO2 FVC (%), slope, VO2 FEV1 (%), at ventila- FEV1/FVC tory					T: 45 min				Between	
IMT: peak VO2, IC lung, IMT: VE/VCO2 FVC (%), I: 60% of slope, VO2 FEV1 (%), SMIP at ventila- FEV1/FVC F: 2-3x/wk tory tory					F: 3-5x/wk			Con: \leftrightarrow	groups: \leftrightarrow	
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I: 60% of slope, VO2 FEV1 (%), SMIP at ventila- FEV1/FVC F: 2-3x/wk tory tory					IMT:			VE/VCO ₂	FVC (%),	
SMIP at ventila- FEV1/FVC F: 2-3x/wk tory					I: 60% of			slope, VO ₂	FEV ₁ (%),	
F: 2-3x/wk tory					SMIP			at ventila-	FEV ₁ /FVC	
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Bosnak- Guclu et al, ¹⁷ 2011	30 CHF Exp= 16 Age: 69.50±7.9 6 yr Con= 14 Age: 65.71±10. 52 yr NYHA: II- III	Sham -IMT	IMT	6 wk Exp: I: 40% of MIP ad- justed weekly to maintain 40% of MIP Con: I: 15% of MIP T:30 min/d F: 7x/wk RR: 25-30 breaths at each work- load	Exp: 1balance, 1QFMS, 1QFMS (%) Con: \leftrightarrow QFMS, QFMS (%), bal- ance Between groups: Exp 1QFMS 1balance Vs Con	Exp: $1MIP$, 1MIP (%), 1MEP, 1MEP (%) Con: $1MIP$, 1MIP (%), 1MEP \leftrightarrow MEP (%) Between groups: Exp $1MIP$, $1MIP$ (%), $1MEP$ Vs Con	VE, RER, exercise time Between groups: ↔ 6MWT, peak VO ₂ , VO ₂ at ventilatory threshold, VE/VCO ₂ slope, VE, RER, exer- cise time Exp: 16MWT, 6MWT (%) Con: ↔ 6MWT Between groups: Exp 16MWT, 6MWT, 6MWT (%) Vs Con	Exp: \uparrow FVC (%), \uparrow FEV ₁ (%), \leftrightarrow FEV ₁ /FVC Con: \uparrow FVC (%), \leftrightarrow FEV ₁ /FVC Between groups: Exp \uparrow FEV ₁ /FVC Vs Con \leftrightarrow FEV ₁ (%), FVC(%)	Exp: \downarrow fa- tigue, \uparrow Qol, \downarrow dyspnea, Con: \uparrow Qol \leftrightarrow dyspnea, fatigue Between groups: Exp \downarrow dysp- nea Vs Con \leftrightarrow fatigue, Qol
Adamopo ulos et al, ¹⁸ 2014	43 CHF Exp= 21 Age: 57.8 ± 11.7 yr Con= 22 Age: 58.3±13.2 yr NYHA: II- III	AT/S HAM- IMT	AT/IMT	12 wk F: 3x/wk AT for both groups: I: 70-80% max HR T: 45 min Exp: I: 60% of SMIP T:30 min		Exp: ↑SMIP, ↑MIP Con: ↑MIP, ↔SMIP Between groups: Exp: ↑SMIP, ↔ MIP Vs Con	Exp: \uparrow peak VO ₂ , \uparrow ex- ercise time, \uparrow VE, \uparrow RER \leftrightarrow VE/VCO2 slope, VT, CP Con: \uparrow peak VO ₂ \leftrightarrow VE/VCO ₂ slope, VT, VE, RER,	Exp: \leftrightarrow FEV ₁ , FEV1/FVC, FVC Con: \leftrightarrow FEV ₁ , FEV ₁ /FVC, FVC Between groups: \leftrightarrow FEV ₁ , FEV ₁ /FVC, FVC, FVC	Exp: $1Qol$, 1LVEF (%), $\downarrow LVESD$, $\downarrow NYHA$, $\downarrow dyspnea$ $\leftrightarrow LVEDD$ Con: $1LVEF$ (%), $\downarrow LVESD$, $\downarrow NYHA$ $\leftrightarrow Qol$, LVEDD, dyspnea Between groups:

				TIRE Proto- col: 6 inspir- atory efforts at each level: Level 1-60s R Level 2- 45s R Level 3-30s R Level 4-15s R Level 5- 10s R Level 6-5s R (to exhaustion) Con I: 10% of SMIP T: 30 min		exercise time, CP Between groups: ↔ VE/VCO ₂ slope, VT, VE, RER, exercise time, CP, peak VO ₂	Exp ↑Qol, ↓Dyspnea Vs Con ↔ LVEDD, LVESD, LVEF (%), NYHA
Moreno et al, ¹⁹ 2017	26 CHF Exp= 13 Age: 61±14 yr Con= 13 Age: 60±13 yr NYHA: II- III	Sham -IMT	IMT	8 wk F: 6x/wk T: 30min/d Exp: I: 30% of MIP RR: 15 breaths/min Con: I: 2% of MIP IMMP: IRT set at 60% of MIP for 1 min after ↑ to 70%, 80% and 90% of MIP until fa- tigue	Exp:1MIP Con: ↔ MIP Between groups: IMT ↑ MIP Vs Con	Exp: 1VO ₂ Con: 1VO ₂ Between groups: ↔ VO ₂	Exp:↑Qol Con: ↔ Qol Between groups: Exp ↑Qol Vs Con
Hossein Pour et al, ²⁰ 2019	84 CHF Exp= 42 Age: 55.97±9.4 3 yr Con= 42 Age: 57.28±9.0 6 yr NYHA: II- III/IV	Sham -IMT	IMT	6 wk F: 1x/d, 7d/wk T: 30 min, 3 min sets of training R: 1 min/set Exp: I: 40% of MIP			Exp: ↓NYHA, ↓dyspnea Con: ↑dysp- nea, ↔ NYHA Between groups: Exp ↓dyspnea, fatigue, NYHA Vs Con

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Mello et	27 CHF	No	IMT	Training load ad- justed to maintain 40% of MIP weekly Con: l: 10% of MIP 12 wk	Exp:	Exp: †MIP	Exp: ↑peak	Exp: †Qol
al, ²¹ 2012	Exp= 15 Age: 54.3 ±2 yr Con= 12 Age: 53.3 ±2 yr	inter- ven- tion		F: 3x/d, 7x/wk T: 10 min Exp: I: 30% of MIP Con: no in- spiratory Ioad	↑MSNA Con:↔ MSNA Between groups: Exp ↔ MSNA Vs Con	Con ↔ MIP Between groups: Exp ↑MIP Vs Con	VO_2 , $\downarrow VE/VCO_2$ peak $\downarrow VE/VCO_2$ slope $Con \leftrightarrow$ peak VO_2 , VE/VCO_2 slope, VE/VCO_2 peak Between groups: $Exp \uparrow peak$ VO_2 , $\downarrow VE/VCO_2$ peak, $\downarrow VE/VCO_2$ slope VS Con	Con: ↔ Qol Between groups: Exp ↑Qol Vs Con
Hornikx et al, ²² 2020	20 CHF Exp=10 Age: 64±8 yr Con=10 Age: 58±11 yr	T	RHIIT (RT/HII T/IRT)	12 wk F: 3x/wk Con: I: 50% Wpeak (3 min warm up, 2x7 min cycling, 2x7 min walking in treadmill, 12 min: row- ing, step and armergome- try) RT: callis-	Exp: ↑QFMS Con: ↔QFMS Between groups: Exp ↑QFMS Vs Con	Exp: ↑MIP Con: ↔ MIP Between groups: Exp ↑MIP Vs Con	Exp: \uparrow peak VO ₂ , \leftrightarrow VE/VCO ₂ Con: \uparrow VO ₂ peak, \leftrightarrow VE/VCO ₂ Between groups: \leftrightarrow peak VO ₂ , VE/VCO ₂	Exp: ↑Qol Con: ↔ Qol Between groups: ↔ Qol

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Chen et al, ²³ 2016	21 CHF Exp= 11 Age: 63.73 ±14.64 yr Con= 10 Age: 67.50± 10.35 yr	Stroke reha- bilita- tion pro- gram	IMT	thenics exer- cises (20 min) Exp: HIIT: cycling I: 80% of Wpeak T: 33 min RT: I: 65 % of 1RM (2 set/10 rep on a leg press) IRT: F: 2x/d I:50% of MIP RR: breath in & out 30 times 10 wk F: 1x/d, at least 5x/wk T:30 min Exp: I: 30% of MIP with ↑ 2cmH ₂ O each wk Exp+Con: participated in a conven- tional stroke rehabilita- tion pro- gram Con: did not receive any IMT		Exp: \uparrow MIP, \leftrightarrow MEP Con: \leftrightarrow MIP, MEP Between groups: Exp \uparrow MIP, \leftrightarrow MEP Vs Con		Exp: \uparrow FVC, \uparrow FEV ₁ , \leftrightarrow FEV ₁ /FVC Con: \leftrightarrow FEV ₁ /FVC Between groups: \leftrightarrow FEV1, FVC, FEV1, FVC, FEV1/FVC	
Kawauchi et al, ²⁴ 2017	35 CHF Exp1= 13Age: 54±10 yr Exp2= 13 Age: 56±7 yr	No inter- ven- tion	Exp ₁ = LIPRT (IMT/R T) Exp ₂ = MIPRT	8 wk F: 7d/wk LIPRT: IMT: I: 15% of MIP RT: 0.5 kg (upper &	Exp ₁ : [↑] Quadri- ceps strength Exp _{1,2} : [↑] Quadri- ceps strength	Exp1: ↑MEP, ↑MIP Exp2: ↑MIP, ↑MEP Con: ↔ MIP, MEP	Exp1: ↑6MWT Exp2: ↑6MWT Con: ↔ 6MWT	Within & Between groups: \leftrightarrow FEV ₁ (%), FVC (%), FEV ₁ /FVC	Exp ₁ : \uparrow Qol, \leftrightarrow NYHA Exp ₂ : \uparrow Qol, \downarrow NYHA Con: \uparrow Qol, \leftrightarrow NYHA

	Con= 9 Age: 56±7 yr NYHA: II/III		(IMT/R T)	exercises), 10 rep/exer- cise during first 2 wk, 2set/10 rep for the re- maining 6 wk MIPRT: IXT: I: 30% of MIP RT: 50% of 1RM	(1RM) Vs Con	Between groups: Exp1 ↑MIP, ↔ MEP Vs Con Exp2 ↑MIP, ↑MEP Vs Con	Between groups: Exp _{1,2} ↑6MWT Vs Con	Between groups: ↔ Qol, NYHA
Antunes- Correa et al, ²⁵ 2020	33 CHF Exp1= 11 Age: 55±3 yr Exp2= 12 Age: 57±2 yr Con= 10 Age: 57±3 yr NYHA: II- III	No inter- ven- tion	Exp ₁ = IMT Exp ₂ = AT	4 mo Exp ₁ : I: 60% of MIP F: 5x/wk T: 30 min RR: 15-20 breaths/min Exp ₂ : F: 3x/week Each session included: 5 min stretch- ing exer- cises, 40 min of cycling, 10 min strengthen- ing exercises R: 5 min		Exp ₁ : \uparrow MIP Exp ₂ : \leftrightarrow MIP Con: \leftrightarrow MIP Between groups: Exp ₁ \uparrow MIP Vs Con Exp ₂ \leftrightarrow MIP Vs Con	Exp1: \uparrow peak VO2 , \uparrow peak workload Exp2: \uparrow peak VO2, \uparrow peak workload Con: \uparrow peak workload, \leftrightarrow peak VO2 Between groups: Exp1,2 \uparrow VO2 peak Vs Con Exp 2 \uparrow peak workload Vs Con Exp1 \leftrightarrow peak work- loadVs Con	Exp1: ↑Qol Exp2: ↑Qol Con: ↑Qol Between groups: Exp1,2 ↑Qol Vs Con
Palau et al, ²⁶ 2014	26 CHF (HFpEF) Exp= 14Age: 68 (60–76) y	Usual care	IMT +Usual care	12 wk F: 2x/d T: 20 min Exp: I: 25-30% of MIP		Exp:↑MIP Between: Exp:↑MIP Vs Con	Exp: ↑peak VO ₂ , ↑VO ₂ AT, ↓VE/VCO ₂ slope, ↑RER, ↑6MWT	Exp: \uparrow Qol, \leftrightarrow LVEF (%) Con \leftrightarrow LVEF (%), Qol Between groups: Exp

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	Con=					$Con \leftrightarrow$	↑Qol Vs Con,
	12Age: 74					VE/VCO ₂	\leftrightarrow LVEF (%)
	(73–77) yr					slope, VO ₂	
						AT, ↓peak	
	NYHA:					VO ₂ ,	
	III/IV					6MWT	
						. .	
						Between	
						groups:	
						Exp ↑peak	
						VO₂, ↑VO₂	
						AT,	
						VE/VCO ₂	
						slope	
						1 6MWI,	
						↑RER Vs	
						Con	
Palau et	59	cual	Exp.:	12 WK & G		Evn.:	Evn₁: tOol
27 2010	(UEnEE)	caro	схрі. Імит	nz wk & u		tpoak VO	(2.8, 6, mo)
ai, 2019	(пгрсг)	Care	(homo			$(2 \ \text{e} \ \text{f} \ \f} \ \text{f} \ \f} \ \f} \ \text{f} \ \f} \ \f} \ \text{f} \ \f} \ \f} \ \f$	(3 & 0 110)
	Con= 13		(nome	up			Exp₂: ↑Ool (3
			based)	Exp₁:		$\sqrt{VE/VCO_2}$	mo). \leftrightarrow Ool
	Exp1= 15		Exp ₂ :	E: 2x/d		siope (6	(6 mo)
	Exp2= 15		EXP2.	T: 20		mo) ♠ as us = sa	(0 1110)
	Exp3= 16		Fynat	min/session		16MWI (3	Exp₃ : ↑Qol
	Age: 74±9		цит	1. 25% to		& 6 mo),	(3 & 6 mo)
	yr			20% of their		\leftrightarrow	
	,		TES			VE/VCO ₂	Between
	NYHA: II-			IVIIF		slope (3	groups:
	III/IV			Exp ₂ : FES		mo)	_
				program for		Evne	Exp _{1,2,3}
				both legs		tneak VOa	groups 1 Qol
				T: 45 min		(3 & 6 mo)	(3 mo) Vs
				F: 2d/wk for		(3 & 0 mo) ↑6м/м/т (2	Con
				a total of 12			\leftrightarrow LVEF (%),
				wk		& 0 mo),	LVEDD,
				Stimulator:			LVESD
				F: 10 to		slone (3.8)	
				50Hz for 5s		slope (5 &	
				R: 5s		01110)	
						Exp ₃ :	
				Exp3: re-		1peak VO₂	
				ceived IMT		(3 & 6 mo)	
				and FES		↓VE/VCO ₂	
				training at		slope (3	
				the same		mo)	
				time		,, 16MWT (3	
						& 6 mo)	
						\leftrightarrow	
						VL/VCO2	

						slope (6	
						mo)	
						Between	
						groups:	
						Exp _{1,2,3}	
						groups	
						↑peak VO ₂	
						(3 & 6 mo)	
						Vs Con	
						Exp _{1,2,3}	
						groups	
						16MWT (3	
						mo) Vs	
						Con. at 6	
						mo this	
						heneficial	
						offocts	
						nercisted	
						for Eve	
						for $exp_{2,3}$	
						↔ peak	
						VO	
						slope be-	
						tween	
						Exp _{1,2,3}	
						groups	
Fkman et	65 CHE	Music	DGB	4 wk		groups	Fxn: ↓dysn-
Ekman et al ²⁸ 2011	65 CHF	Music	DGB	4 wk		groups	Exp:↓dysp-
Ekman et al, ²⁸ 2011	65 CHF Exp= 30	Music lis-	DGB	4 wk Exp:		groups	Exp: ↓dysp- nea, ↓NYHA
Ekman et al, ²⁸ 2011	65 CHF Exp= 30	Music lis- ten-	DGB	4 wk Exp: DGB exer-		groups	Exp: ↓dysp- nea, ↓NYHA Con: ↔
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises		groups	Exp: ↓dysp- nea, ↓NYHA Con: ↔ dyspnea,
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age:	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d		groups	Exp: ↓dysp- nea, ↓NYHA Con: ↔ dyspnea, NYHA Porponders
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Evp. (co.
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session		groups	Exp: ↓dysp- nea, ↓NYHA Con: ↔ dyspnea, NYHA Responders in Exp (an
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II-	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10		groups	Exp: ↓dysp- nea, ↓NYHA Con: ↔ dyspnea, NYHA Responders in Exp (an average in-
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a reduction in
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a reduction in the average
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a reduction in the average respiration
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a reduction in the average respiration rate):
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of > 0.2 and a reduction in the average respiration rate): \downarrow breathless-
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a reduction in the average respiration rate): \downarrow breathless- ness, \downarrow NYHA
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a reduction in the average respiration rate): \downarrow breathless- ness, \downarrow NYHA compared
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a reduction in the average respiration rate): \downarrow breathless- ness, \downarrow NYHA compared with no-re-
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of > 0.2 and a reduction in the average respiration rate): \downarrow breathless- ness, \downarrow NYHA compared with no-re- sponders or
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of > 0.2 and a reduction in the average respiration rate): \downarrow breathless- ness, \downarrow NYHA compared with no-re- sponders or controls
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of >0.2 and a reduction in the average respiration rate): \downarrow breathless- ness, \downarrow NYHA compared with no-re- sponders or controls
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: \downarrow dysp- nea, \downarrow NYHA Con: \leftrightarrow dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of > 0.2 and a reduction in the average respiration rate): \downarrow breathless- ness, \downarrow NYHA compared with no-re- sponders or controls Between
Ekman et al, ²⁸ 2011	65 CHF Exp= 30 Con= 35 Age: 73±11 yr NYHA: II- IV	Music lis- ten- ing	DGB	4 wk Exp: DGB exer- cises F: 2x/d T: 20 min/session RR: <10 breaths/min Con: listened music		groups	Exp: ↓dysp- nea, ↓NYHA Con: ↔ dyspnea, NYHA Responders in Exp (an average in- crease in Tex/Tin of > 0.2 and a reduction in the average respiration rate): ↓breathless- ness, ↓NYHA compared with no-re- sponders or controls Between groups ↔

							dyspnea, NYHA
Drozdz et	40 CHF	Usual	DGB	Exp1: started			Exp1: ↑Qol
al, ²⁹ 2016		care		with 10-12			
	Exp1= 20			wk			Exp2:↔ Qol
	Exp2 = 20			SBT followed			Between
	Age: 63.3			by 10-12 wk			aroups ↔
	± 13.4 yr			usual care			Qol
	NYHA: II-			Exp ₂ : started			
	Ш			with 10-12			
				wk usual			
				care fol-			
				lowed by			
				10-12 wk			
				SBT			
				SBT			
				F: 2x/d			
				T: 15			
				min/session			
				RR: 6			
				breaths/min			
See at al ³⁰		۸+	ספר	9 wk 8 E mo		Eve	Even & Cont
2015	30 CHF	Al-	DDR	6 WK Q 5 IIIO		темиит (8	dyspnes (8)
2013	Exp=18	tion		TOHOW UP		wk & sus-	wk & 5 mo)
	Age:	arou		Exp: received		tained at 5	wk & 5 mo)
	65.2±11.3	n		3 audio CDs		mo follow	Between
	4 yr	٢		(1 each for		(au	groups: \leftrightarrow
				wk 1, wk 2,		-1-7	dyspnea (8
	Con= 18			& wk 3-8)		Con:↑6MW	weeks & 5
	Age:			RR: 6		T (8 wk)	mo)
	00.0±15.0 9.vr			breaths/min		Retween	
	5 91			F [.] 2x/day at		aroups. \leftrightarrow	
	NYHA: II-			least 5 d/wk		6MWT (8	
	IV			Week 1 goal:		weeks & 5	
				5 min of CD-		mo)	
				guided DBR			
				Week 2 goal:			
				10 min of			
				CD-guided			
				DBR			
				Weeks 3-8			
				goal: 15 min			
				of CD-			
				guided DBR			
				+ 4 tele-			
				phone calls			
				(feedback &			
				encourage)			

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				Con: re-			
				ceived 4 tel-			
				ephone calls			
				, with general			
				health topics			
Kawecka-	96 CHF	Usual	DGB	Exp ₁ : started		After SBT:	After SBT:
Jaszcz et	Age: 64.5	care		with 10-12		↑6MWT	↑ef, ↑lvef
al, ³¹ 2017	(57.0–			wk			(%), ↓LVEDD
	71.5) yr						
				SBT followed			
	NYHA: I-III			by 10-12 wk			
				usual care			
				Expe: started			
				Exp_2 . Started			
				wkusual			
				wk usual			
				Lowed by			
				10 12 wk			
				IU-IZ WK			
				201			
				SBT:			
				F: 2 x/day			
				T: 15			
				min/session			
				RR: 6			
				breaths/min			
				,			
Lachowska	21 HFrEF		DGB	12 wk & 6		SLOWB	SLOWB:
et al, ³²				mo follow		from base-	
2019	Exp= 11			up		line to 6	\leftrightarrow LVEF (%),
	Con=			SBT:		mo follow	LVEDD (3 &
	10Age:			F: 2x/d		up:	6 mo)
	52±17 yr			T: 15		↑6MWT &	
	ΝΥΗΑ· Ι-ΙΙΙ			min/session		peak RER	
				(totally 30		in Group 1	
				min)		but no	
				RR: 10		Group 2	
				breaths/ min		\leftrightarrow peak	
						VO ₂ ,	
				At 3 mo fol-		VE/VCO ₂	
				low up-		from base-	
				Group ₁ : con-		line to 3	
				tinue SBT		mo follow	
				Group ₂ : no		up	
				SBT			
				501			

Abbreviations:

Exp: experimental, Con: control, IMT: inspiratory muscle training, SBT: slow breathing training, DGB: device-guided breathing, IMMP: inspiratory muscle metaboreflex protocol, LVEF: left ventricular ejection fraction, LVESD: left ventricular end-systolic diameter, LVEDD: left ventricular end-diastolic diameter, HR: heart rate, I: intensity, R: rest, F: frequency, T: time, RR: respiratory rate, MSNA: muscle sympathetic nerve activity, LIPRT: low intensity inspiratory and peripheral resistance training, RT: resistance training, IRT: inspiratory resistance training, HIIT: high intensity interval training, MIPRT: moderate-intensity inspiratory and peripheral resistance training, DBR: diaphragmatic breathing retraining, RER: respiratory exchange ratio, SMIP: sustained maximal inspiratory pressure, MEP: maximal expiratory pressure, FEV₁: forced expiratory volume in 1 s, FVC: forced vital capacity, QFMS: quadriceps femoris muscle strength, QMT: quadriceps muscle torque, QME: quadriceps muscle endurance, CP: circulatory power, VT: ventilatory threshold, VE: minute ventilation, TG: training group, IC: inspiratory capacity, EF: ejection fraction, peak VO₂: peak oxygen consumption, VE/VCO₂: ventilation/carbon dioxide, 6MWT: 6 min walk test, 1RM: 1 repetition maximum, Rep: repetition, NYHA: New York Heart Association, QoI: quality of life, ↔: no changes, ↑: increased, ↓: reduced, %: predicted