Treinamento do Músculo Inspiratório em Pacientes com Insuficiência Cardíaca e Doença do Músculo Inspiratório

Apresentado por Priscila Mello

na reunião da Unidade de Hipertensão do Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo

em 25 de Fevereiro de 2009

Inspiratory Muscle Training in Patients With Heart Failure and Inspiratory Muscle Weakness

A Randomized Trial

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OBJECTIVES This study sought to evaluate the effects of inspiratory muscle training in inspiratory muscle strength, as well as in functional capacity, ventilatory responses to exercise, recovery oxygen uptake kinetics, and quality of life in patients with chronic heart failure (CHF) and inspiratory muscle weakness.

BACKGROUND Patients with CHF may have reduced strength and endurance in inspiratory muscles, which may contribute to exercise intolerance and is associated with a poor prognosis.

METHODS Thirty-two patients with CHF and weakness of inspiratory muscles (maximal inspiratory pressure [PI_{max}] <70% of predicted) were randomly assigned to a 12-week program of inspiratory muscle training (IMT, 16 patients) or to a placebo-inspiratory muscle training (P-IMT, 16 patients). The following measures were obtained before and after the program: PI_{max} at rest and 10 min after maximal exercise; peak oxygen uptake, circulatory power, ventilatory oscillations, and oxygen kinetics during early recovery ($\dot{V}O_2$/t−slope); 6-min walk test; and quality of life scores.

RESULTS The IMT resulted in a 115% increment PI_{max}, 17% increase in peak oxygen uptake, and 19% increase in the 6-min walk distance. Likewise, circulatory power increased and ventilatory oscillations were reduced. The VO_2/t−slope was improved during the recovery period, and quality of life scores improved.

CONCLUSIONS In patients with CHF and inspiratory muscle weakness, IMT results in marked improvement in inspiratory muscle strength, as well as improvement in functional capacity, ventilatory response to exercise, recovery oxygen uptake kinetics, and quality of life. (J Am Coll Cardiol 2006;47:757–63)

Incidência de Hipertensão e IC

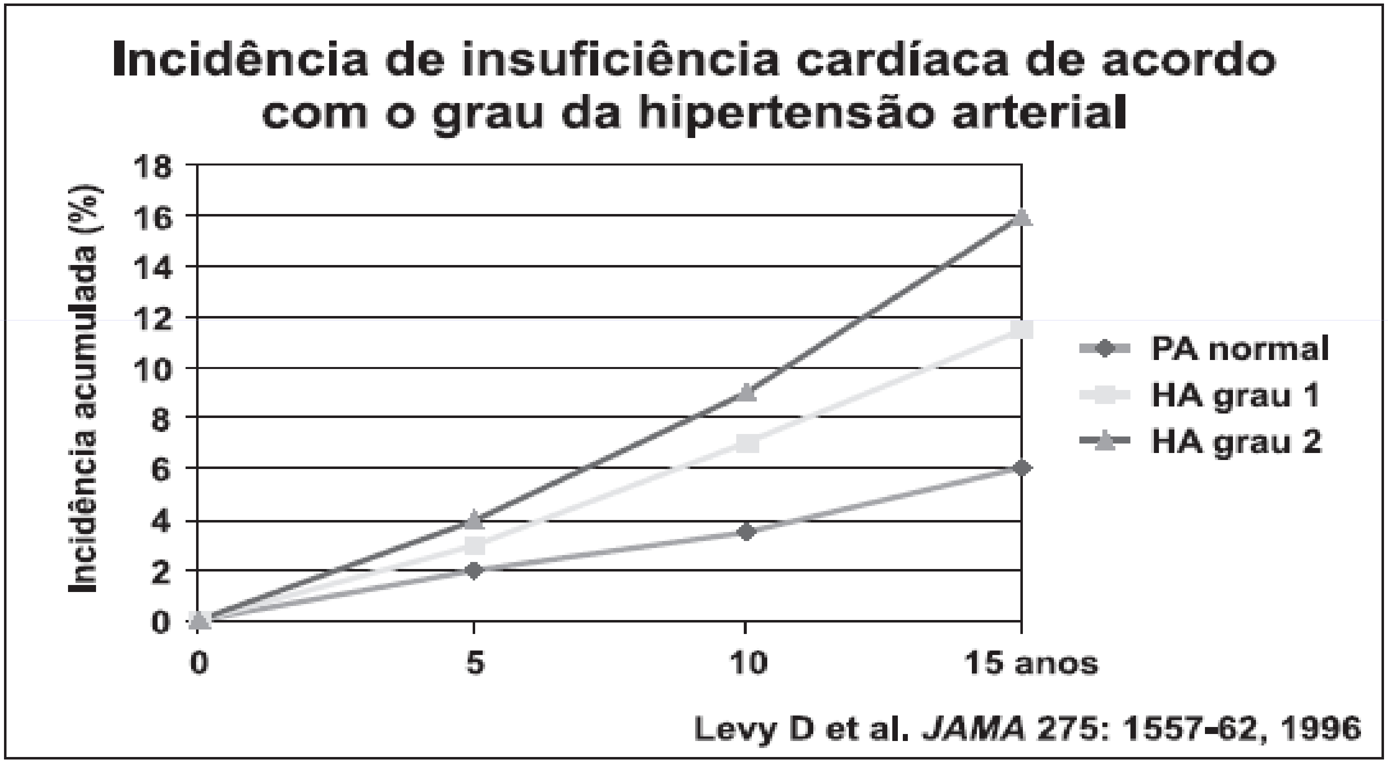

Figura 1 – Quanto mais elevados os níveis pressóricos, maior a incidência de quadros de insuficiência cardíaca. Dados do estudo de Framingham.
PA = pressão arterial; HA = hipertensão arterial.

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- Pacientes com IC possuem limitação relacionada a atividade física – dispnéia;
- Alguns pacientes com IC apresentam diminuída $Pi_{\text{máx;}}$
- A resistência muscular diminuída dos músculos inspiratórios pode estar relacionada a limitação a atividade física;
- As causas relacionadas a alteração muscular ainda são especulativas.

Hipótese

- Pacientes com IC e diminuição da força muscular inspiratória quando submetidos a um programa de TMI melhoram a cinética do consumo de oxigênio no período da recuperação, capacidade funcional e qualidade de vida.

Metodologia

- Foram incluídos no estudo pacientes com IC, fração de ejeção < 45%, $Pi_{máx}$ < 70% e estabilidade clínica ;
- Critérios de exclusão: instabilidade hemodinâmica, alterações cognitivas, angina, doenças pulmonares prévias e infarto agudo do miocárdio prévio

Metodologia

- Espirometria;
- Pressão inspiratória máxima;
- Teste de caminhada de 6 minutos;
- Ergoespirometria;
- Questionário de qualidade de vida;
- Treinamento da musculatura inspiratória.

Pressão inspiratória máxima

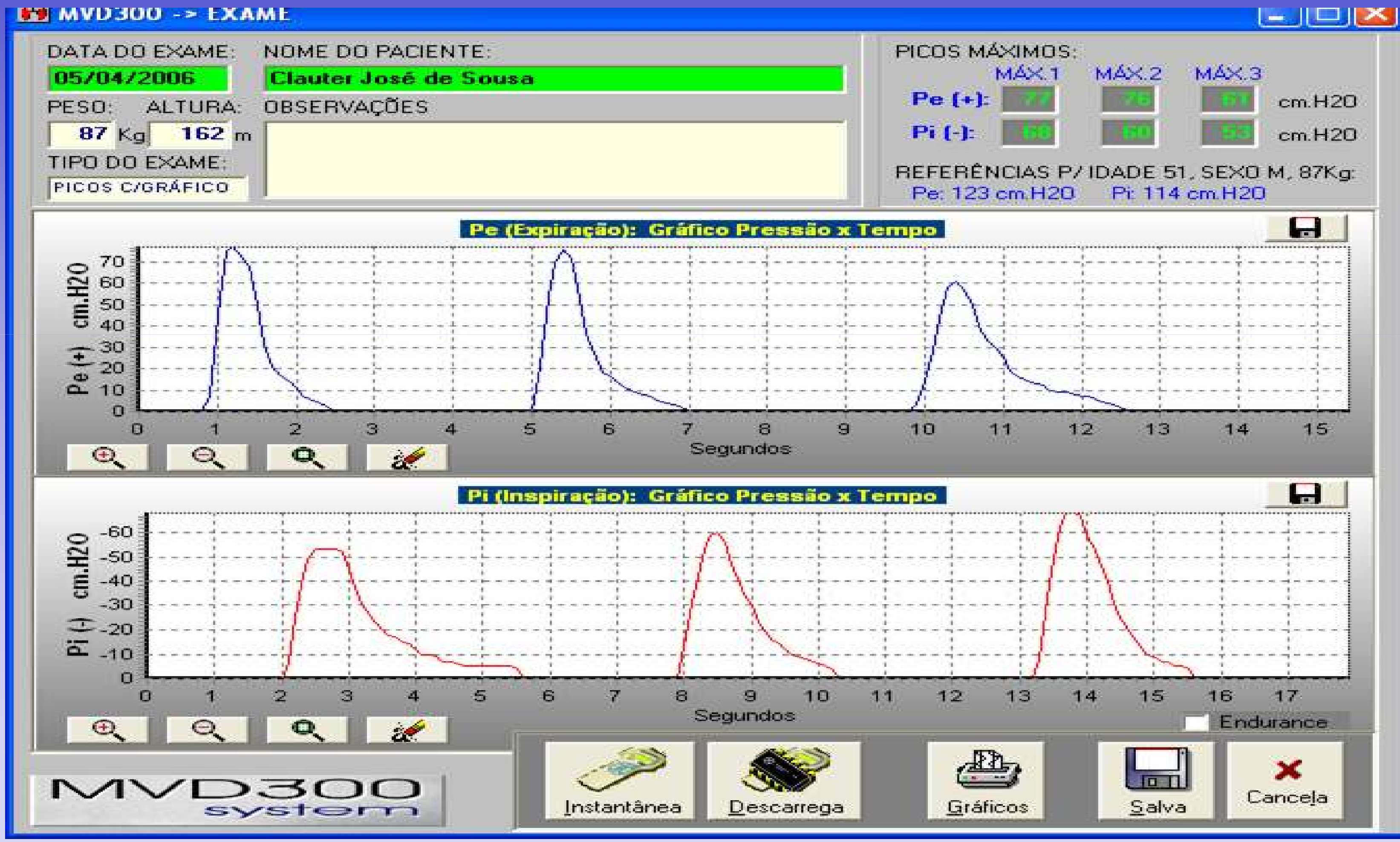

Table 1. Baseline Characteristics of Patients Randomized to P-IMT or IMT

Characteristic	P-IMT Group (n = 16)	IMT Group (n = 16)	p Value*
Gender, male/female	10/6	11/5	0.60†
Age, yrs	58 ± 2	54 ± 3	0.21
Body mass index, $kg \cdot m^{-2}$	27 ± 5	27 ± 4	0.86
Etiology of heart failure, n			
Ischemic	7	6	0.90†
Non-ischemic	9	10	0.60†
Ejection fraction, %	38 ± 3	39 ± 3	0.79*
Forced expiratory volume in 1 s, % predicted	90.1 ± 12.6	83.7 ± 14.5	0.20*
Forced vital capacity, % predicted	84.7 ± 8.8	85.3 ± 13.4	0.96*
PI_{max}, kPa	5.7 ± 0.1	5.9 ± 0.9	0.29*
PI_{max}, % predicted	59.8 ± 2	59.5 ± 2.2	0.89*
$\dot{V}O_2$peak, $ml \cdot kg^{-1} \cdot min^{-1}$	17 ± 0.7	17.2 ± 0.5	0.75*
Drugs, %			
Diuretics	80	86	0.82†
Digoxin	50	57	0.79†
Angiotensin-converting enzyme inhibitors	78	85	0.86†
Beta-blocker	50	42	0.10†

Values are expressed as mean ± standard deviation. *Student *t* test. †Fisher exact test. IMT = inspiratory muscle training; P-IMT = placebo-inspiratory muscle training; PI_{max} = maximal static inspiratory pressure; $\dot{V}O_2$peak = peak oxygen uptake.

Pressão inspiratória máxima

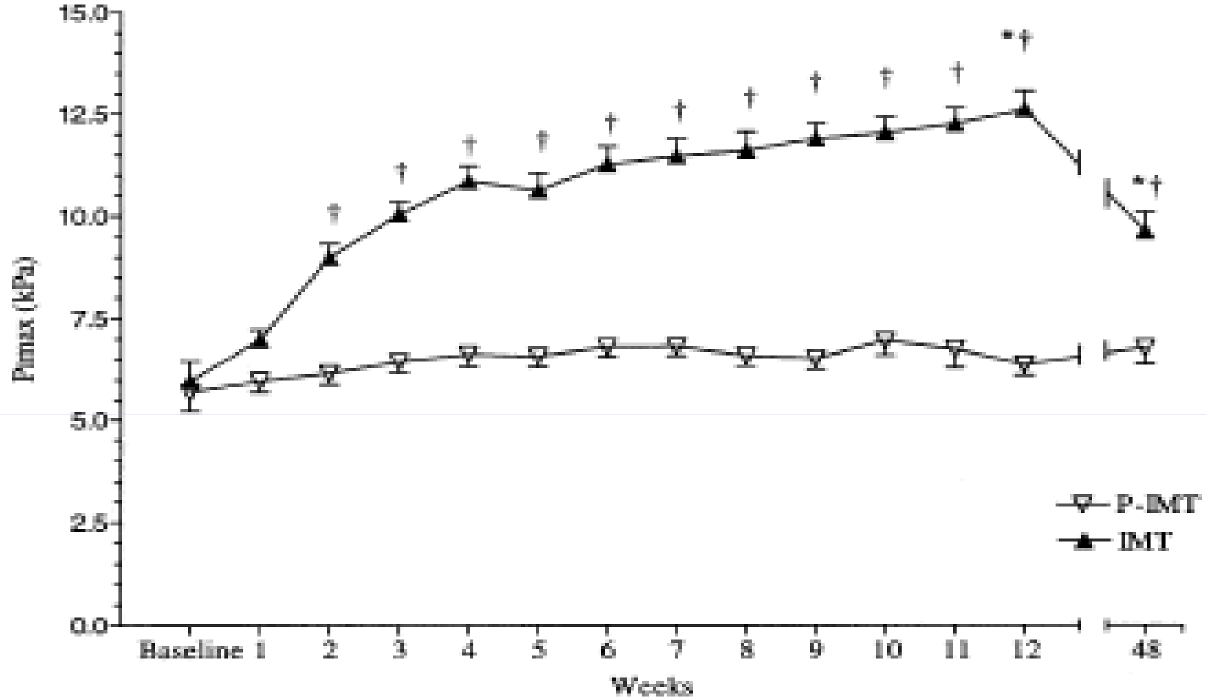

Figure 1. Weekly values of maximal inspiratory pressure (PI_{max}, mean ± SD) for the placebo-inspiratory muscle training group (P-IMT) and for the inspiratory muscle training group (IMT). After 12 weeks in the program, all training was stopped, and 11 patients from each group were re-evaluated at 48 weeks. *Two-way ANOVA for repeated measures: $p < 0.01$ for group, training, and interaction effects. †Significantly ($p < 0.05$) different from baseline evaluation by the Tukey test.

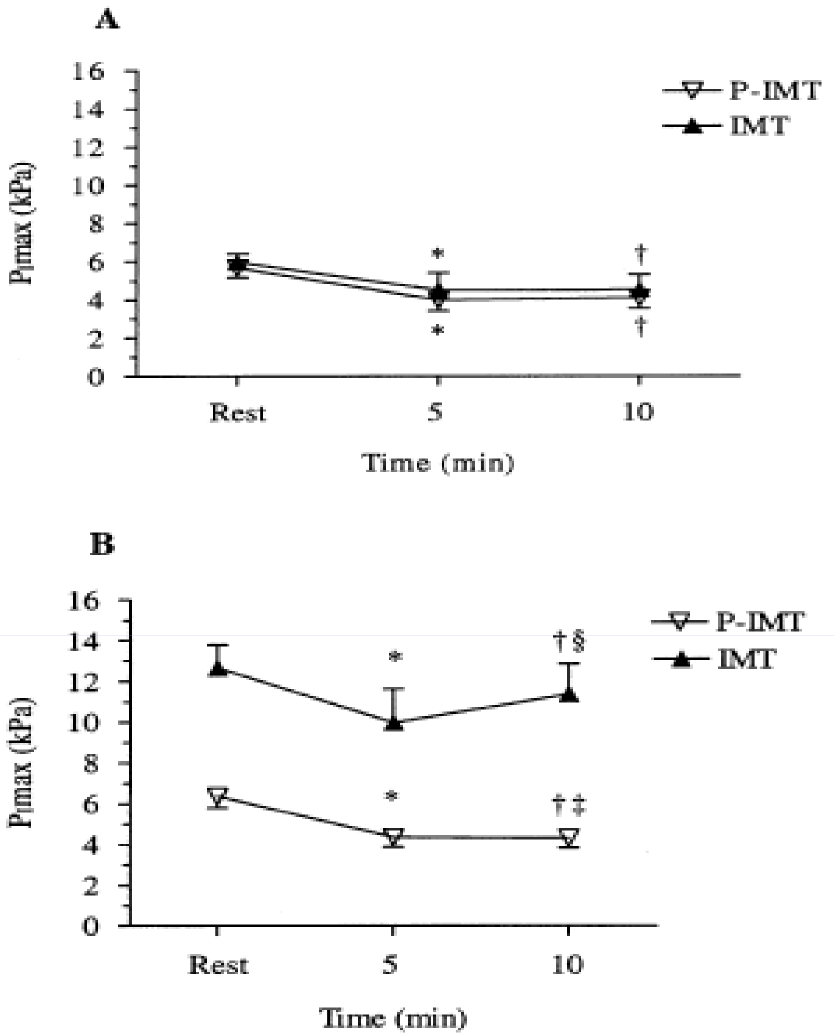

Figure 2. The PI_{max} values (mean ± SD) at rest and on the 5th and the 10th min of recovery after maximal cardiopulmonary exercise test. (A) Values before and (B) after intervention for the placebo inspiratory muscle training group (P-IMT) and the inspiratory muscle training group (IMT). Two-way ANOVA for repeated measurements: §IMT versus P-IMT ($p < 0.01$ for group, training, and interaction effects). Multiple comparisons by the Tukey test: *5th minute versus rest ($p < 0.05$); †10th minute versus rest ($p < 0.05$); ‡10th minute versus 5th min ($p < 0.05$).

$Pi_{máx}$ no repouso, 5 minuto e 10 minuto após ergoespirometria.

Table 3. Results Obtained in the Maximal Cardiopulmonary Exercise Test for the P-IMT and the IMT Group

	P-IMT (n = 16)		IMT (n = 16)	
	Before	After	Before	After
Peak exercise				
$\dot{V}_E$ peak, $l \cdot min^{-1}$	47 ± 3	49 ± 4	48 ± 2.7	62 ± 4*†
$\dot{V}O_2$ peak, $ml \cdot kg^{-1} \cdot min^{-1}$	17 ± 0.6	17 ± 0.8	17 ± 0.6	21 ± 0.7*†
$\dot{V}CO_2$ peak, $l \cdot min^{-1}$	1.3 ± 0.1	1.3 ± 0.1	1.4 ± 0.4	1.5 ± 0.4*†
R peak	1.0 ± 0.02	1.0 ± 0.02	1.0 ± 0.01	1.1 ± 0.02
Peak circulatory power, mm $Hg \cdot ml\ O_2 \cdot kg^{-2} \cdot min^{-1}$	2,714 ± 505	2,592 ± 421	2,829 ± 409	3,696 ± 524*†
Ventilatory efficiency				
$\dot{V}_E/\dot{V}CO_2$ – slope	37 ± 4	37 ± 4	35 ± 3.5	30 ± 3*†
Oscillations in gas exchange				
$\alpha\dot{V}_E$	0.06 ± 0.005	0.06 ± 0.006	0.07 ± 0.005	0.03 ± 0.006*†
$\alpha\dot{V}O_2$	0.01 ± 0.03	0.01 ± 0.004	0.05 ± 0.035	0.04 ± 0.004
$\alpha\dot{V}CO_2$	0.06 ± 0.005	0.07 ± 0.006	0.07 ± 0.004	0.07 ± 0.006
$\alpha\dot{V}O_2/\alpha\dot{V}_E$	1.52 ± 0.27	1.08 ± 0.37	1.8 ± 0.26	2.12 ± 0.35
$\alpha\dot{V}CO_2/\alpha\dot{V}_E$	1.02 ± 0.05	1 ± 0.02	1 ± 0.06	1.18 ± 0.02*†
Recovery gas exchange				
$\dot{V}O_2/t$ – slope 1st min^{-1}	0.48 ± 0.12	0.48 ± 0.10	0.48 ± 0.12	0.81 ± 0.27*†
$T_{1/2}\dot{V}O_2$ (min)	1.55 ± 0.22	1.47 ± 0.35	1.56 ± 0.29	1.04 ± 0.16*†
$T_{1/2}\dot{V}CO_2$ (min)	1.60 ± 0.3	1.59 ± 0.2	1.60 ± 0.3	1.31 ± 0.2*†
$T_{1/2}\dot{V}_E$ (min)	1.63 ± 0.1	1.63 ± 0.2	1.62 ± 0.2	1.33 ± 0.2*†

The values are expressed as mean ± SD. Two-way ANOVA for repeated measures. *$p < 0.001$ for training and interaction effects. †$p < 0.001$ for group effect. *[1]expressed in $l \cdot min^{-1} \cdot min^{-1}$.

α = relative amplitude of oscillations; IMT = inspiratory muscle training; PI_{max} = maximal static inspiratory pressure; P-IMT = placebo inspiratory muscle training; R = respiratory exchange ratio; $T_{1/2}$ = time required for 50% from peak; /t – slope = kinetics during recovery; V_E = minute ventilation; $V_E/\dot{V}CO_2$ – slope = relationship between change in $\dot{V}_E$ and $\dot{V}CO_2$ during incremental exercise; $V_E/\dot{V}O_2$ = ventilatory equivalent for oxygen uptake; $\dot{V}CO_2$ = carbon dioxide output; $\dot{V}O_2$ = oxygen uptake; other abbreviations as in Table 1.

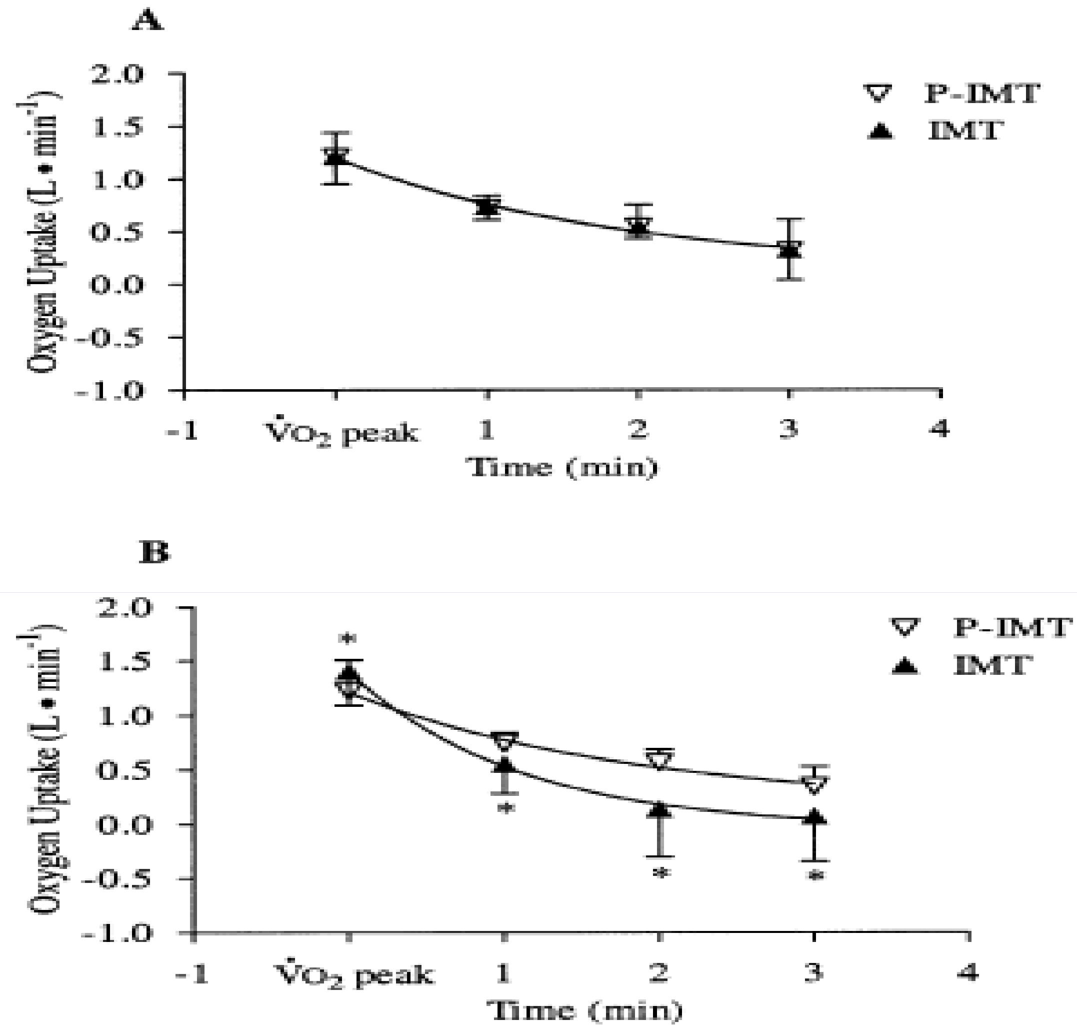

Figure 3. Values of the oxygen uptake kinetics during the first 3 min of recovery (mean ± SD) after maximal cardiopulmonary exercise test before (A) and after (B) intervention for the placebo inspiratory muscle training group (P-IMT) and the inspiratory muscle training group (IMT). Overall two-way ANOVA for repeated measures: $p < 0.001$ for group, training, and interaction effects. *Significantly different between groups ($p < 0.05$) by the Tukey test.

Quality of life. The Minnesota Living With Heart Failure Questionnaire scores improved after IMT (IMT, 27 ± 4 before and 6 ± 2 after; P-IMT, 30 ± 13 before and 30 ±

13 after [ANOVA <0.001 for group, training, and interaction effects]). The global improvement was attributed to a change in physical dimension from 6 ± 3 to 3 ± 5 because no changes were observed in the psychological dimension of

CONCLUSIONS

This randomized, placebo-controlled trial shows that a short-term, home-based program of IMT results in marked improvement in inspiratory muscle strength and endurance, which results in clinically relevant increments of improvement in submaximal and maximal functional capacity, as well as in quality of life in CHF patients with inspiratory muscle weakness. Moreover, IMT also improves ventilatory efficiency and oscillations during exercise, peak circulatory power, and oxygen uptake kinetics during recovery in this patient population.

Inspiratory Muscle Training Improves Blood Flow to Resting and Exercising Limbs in Patients With Chronic Heart Failure

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Objectives We tested the hypothesis that inspiratory muscle loading could result in exaggerated peripheral vasoconstriction in resting and exercising limbs and that inspiratory muscle training (IMT) could attenuate this effect in patients with chronic heart failure (CHF) and inspiratory muscle weakness.

Background Inspiratory muscle training improves functional capacity of patients with CHF, but the mechanisms of this effect are unknown.

Methods Eighteen patients with CHF and inspiratory muscle weakness (maximal inspiratory pressure <70% of predicted) and 10 healthy volunteers participated in the study. Inspiratory muscle loading was induced by the addition of inspiratory resistance of 60% of maximal inspiratory pressure, while blood flow to the resting calf (CBF) and exercising forearm (FBF) were measured by venous occlusion plethysmography. For the patients with CHF, blood flow measurements as well as ultrasound determination of diaphragm thickness were made before and after a 4-week program of IMT.

Results With inspiratory muscle loading, CHF patients demonstrated a more marked reduction in resting CBF and showed an attenuated rise in exercising FBF when compared with control subjects. After 4 weeks of IMT, CHF patients presented hypertrophy of the diaphragm and improved resting CBF and exercise FBF with inspiratory muscle loading.

Conclusions In patients with CHF and inspiratory muscle weakness, inspiratory muscle loading results in marked reduction of blood flow to resting and exercising limbs. Inspiratory muscle training improves limb blood flow under inspiratory loading in these patients. (J Am Coll Cardiol 2008;51:1663–71)

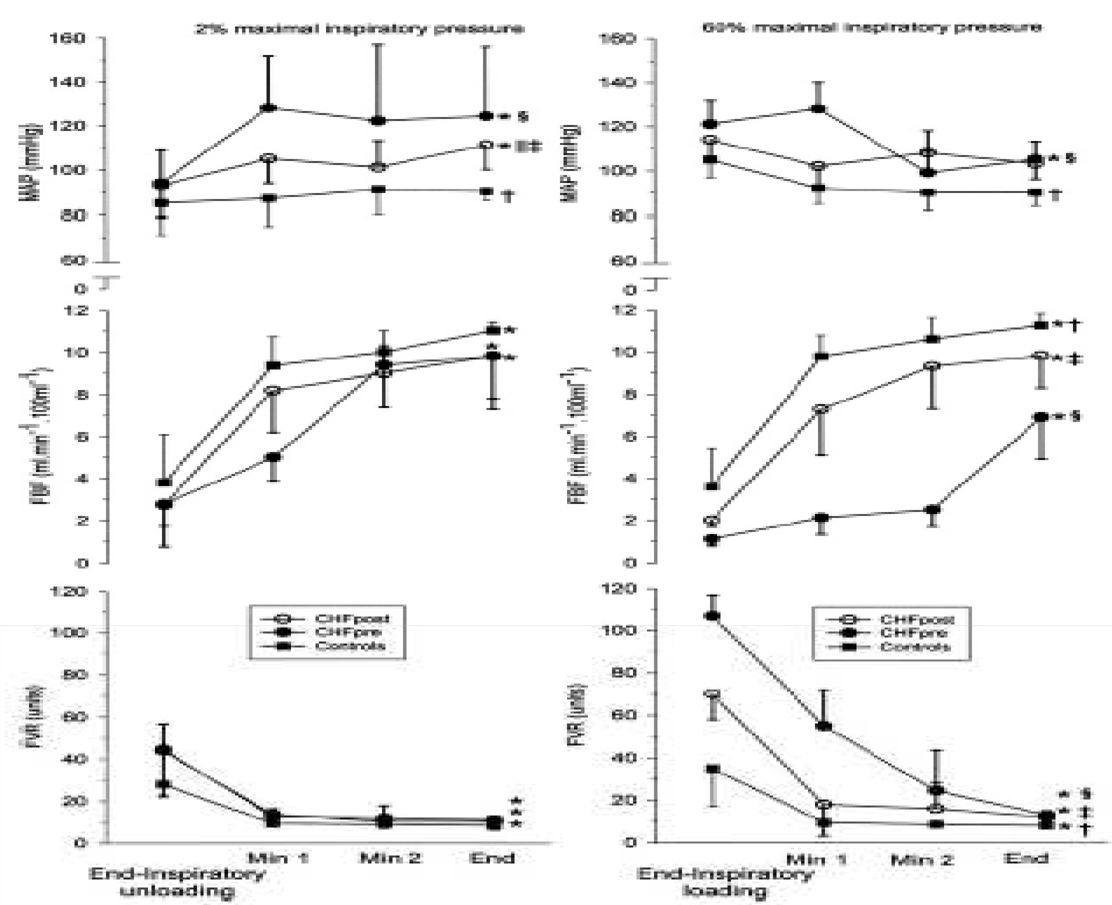

Figure 2 **Hemodynamic Responses to Forearm Exercise After Inspiratory Loading**

Mean (±SD) responses MAP (upper panels), FBF (middle panels), and FVR (lower panels) obtained at rest, minute 1, minute 2, and at the end of handgrip exercise after inspiratory loading protocol, with "placebo loading" (left panels with 2% of maximal inspiratory pressure) and with inspiratory muscle loading (right panels with 60% of maximal inspiratory pressure). Results of 2-way analysis of variance for repeated measures ($p < 0.05$): *time effect; †group effect control versus CHF pre; ‡training status effect CHF pre versus CHF post; §interaction control versus CHF pre; ‖interaction CHF pre versus CHF post. Abbreviations as in Figure 1.