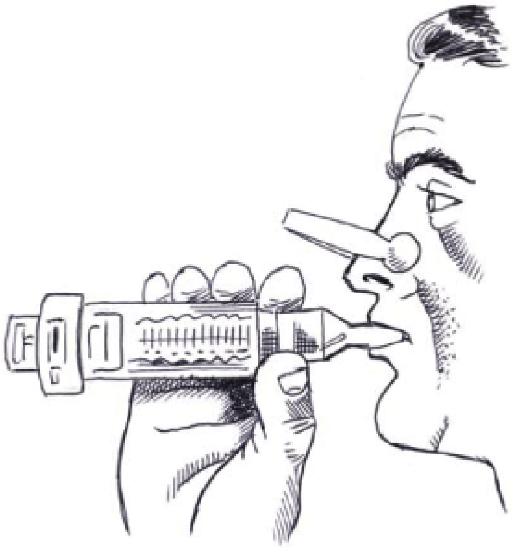
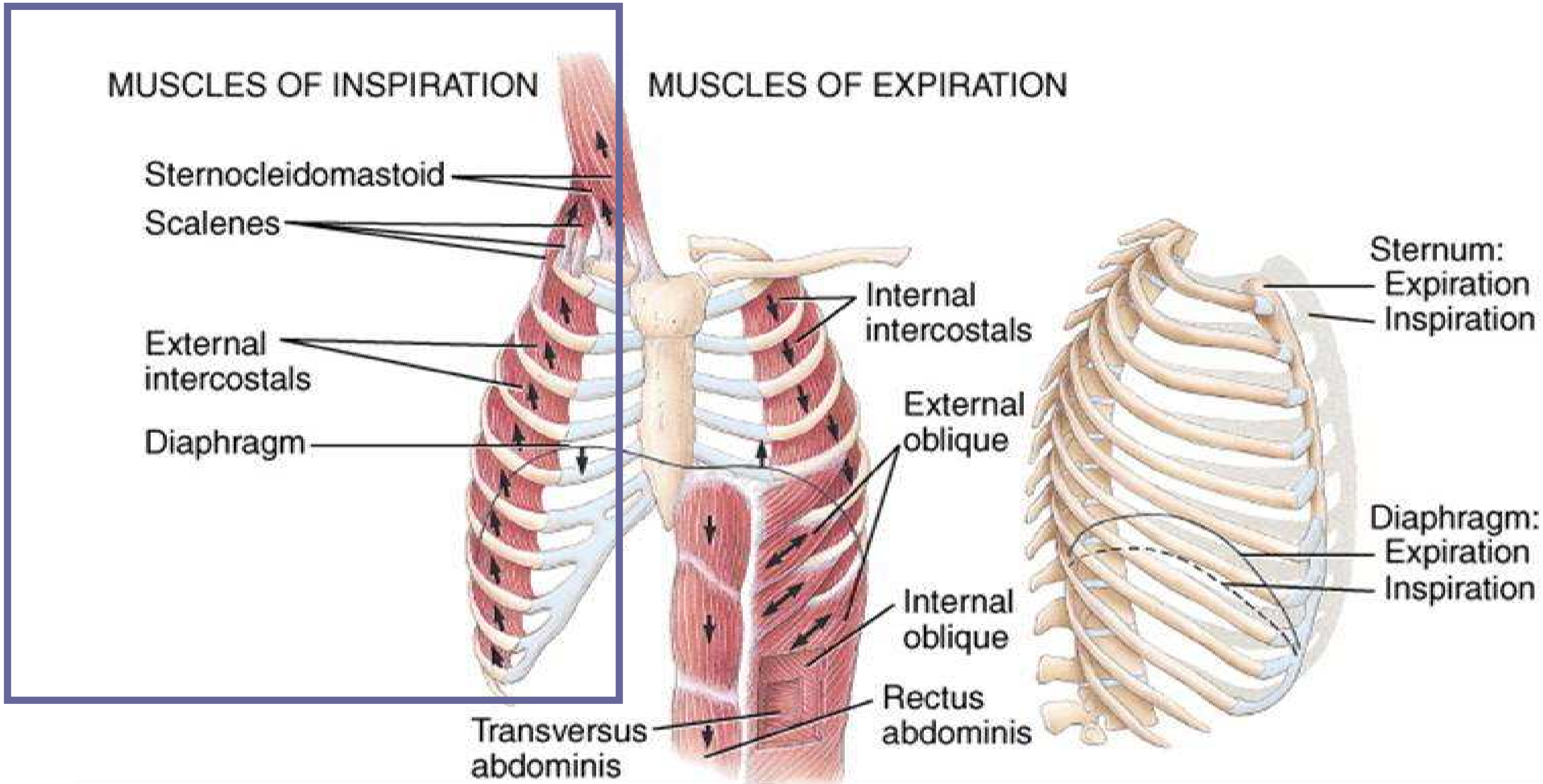
L’allenamento dei muscoli respiratori



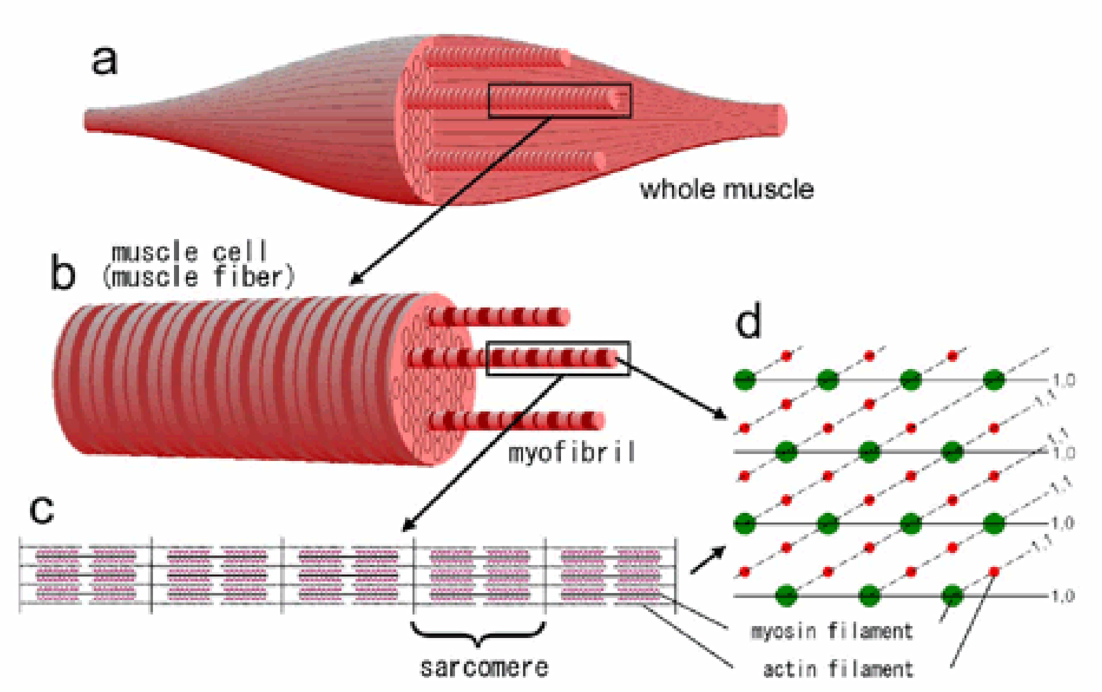
A. Satta

Ente Ospedaliero Cantonale
Lugano

Ospedale Regionale di Lugano



MUSCLES OF INSPIRATION
MUSCLES OF EXPIRATION
Sternocleidomastoid
Scalenes
External intercostals
Diaphragm
Internal intercostals
External oblique
Internal oblique
Rectus abdominis
Transversus abdominis
Sternum:
Expiration
Inspiration
Diaphragm:
Expiration
Inspiration



La risposta del muscolo all'allenamento è:

- specifica
- reversibile

L' allenamento

isotonico e/o isometrico e/o isocinetico

aerobico – anaerobico - misto

forza - resistenza - misto

⇩

modifiche della struttura

modifiche della funzione

I muscoli respiratori: un limite all'esercizio?

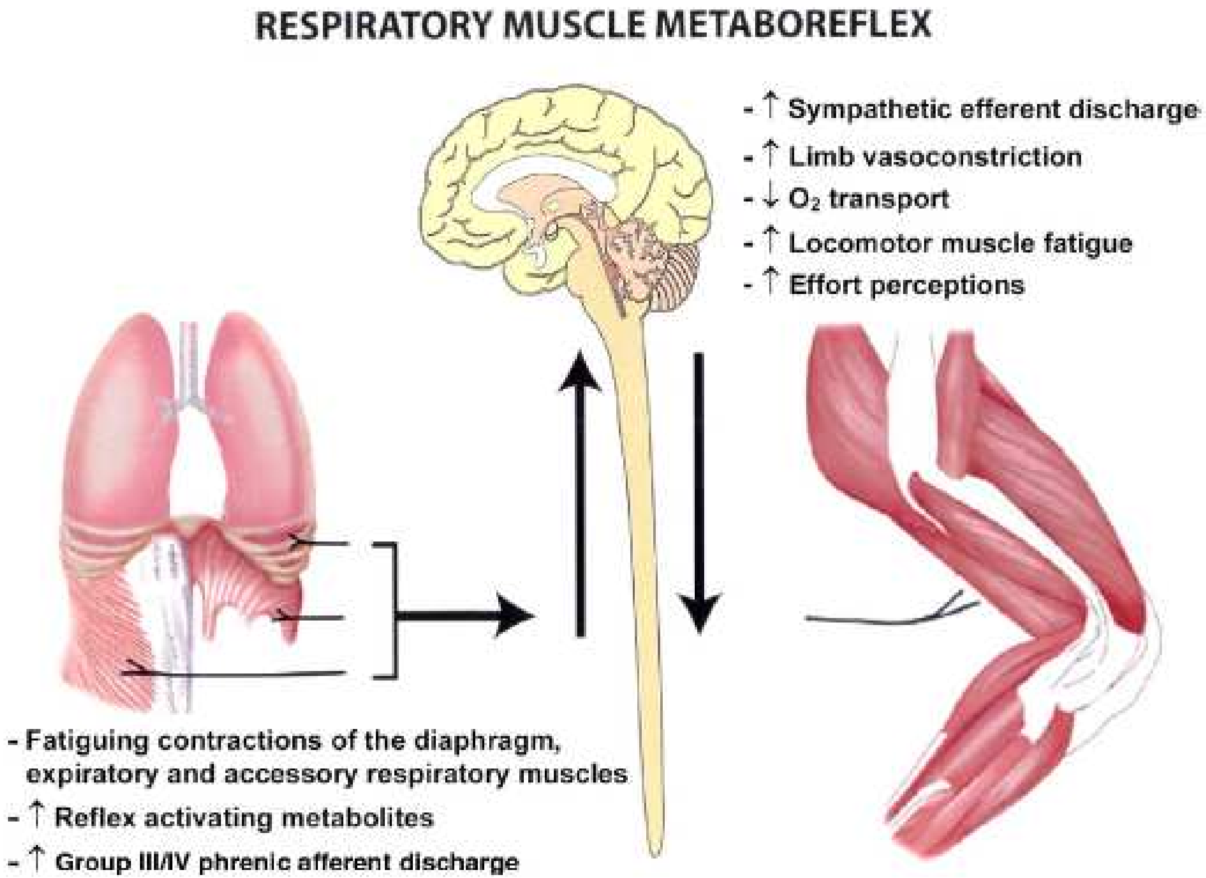
fisiologia

Gli scambi A-a e il trasporto dell'O2 sono limitati durante esercizio strenuo.
Si descrive **exercise-induced arterial hypoxemia** che può limitare la performance dei muscoli periferici: probabilmente anche dei muscoli respiratori

La fatica muscolare interessa anche i muscoli respiratori.
Viene osservata **exercise-induced respiratory muscle fatigue**: può essere coinvolta nel limite al'esercizio

La fatica dei muscoli inspiratori riduce l'apporto circolatorio ai muscoli periferici mediante un **metaboriflesso**: i muscoli respiratori e periferici si influenzano reciprocamente nel generare percezione di fatica

Romer LM, Dempsey JA., Clin Exp Pharmacol Physiol. 2006 Apr;33(4):391-4
Hopkins SR. Adv Exp Med Biol. 2006;588:17-30
Romer LM et Al. Respir Physiol Neurobiol. 2007 Jun 15;156(3):353
Grippo A. J Appl Physiol. 2010 Aug;109(2):367-76..



J Appl Physiol 104: 879–888, 2008.

I muscoli respiratori: un limite all'esercizio?

BPCO

J Appl Physiol 105: 749–757, 2008;
doi:10.1152/japplphysiol.90336.2008.

Point:Counterpoint

Point:Counterpoint: The major limitation to exercise performance in COPD is: *1*) inadequate energy supply to the respiratory and locomotor muscles, *2*) lower limb muscle dysfunction, *3*) dynamic hyperinflation

Aliverti A, Macklem P. Point:Counterpoint: The major limitation to exercise performance in COPD is inadequate energy supply to the respiratory and locomotor muscles.

Debigaré R, Maltais F. Point:Counterpoint: The major limitation to exercise performance in COPD is lower limb muscle dysfunction.

O'Donnell D, Webb K. Point:Counterpoint: The major limitation to exercise performance in COPD is dynamic hyperinflation

John B. West, Peter D. Wagner, J. Alberto Neder, Giorgio L. Scano, Norman L. Jones, Spyros G. Zakynthinos, Ioannis Vogiatzis, Linda Nici, Peter M. Calverley, Harry R. Gosker, Annemie M. W. J. Schols, Paolo Palange, Darcy D. Marciniuk and Scott J. Butcher
J Appl Physiol 105:758-762, 2008. doi:10.1152/japplphysiol.zdg-8100.pcpcomm.2008

1976

Journal of
Applied Physiology

Ventilatory muscle strength and endurance training

D. E. Leith and M. Bradley

Grassino A. Inspiratory muscle training in COPD patients. *Eur Respir J* 1989; 2: Suppl. 7, 581s–586s.

Goldstein RS. Pulmonary rehabilitation in chronic respiratory insufficiency. 3. Ventilatory muscle training. *Thorax* 1993; 48: 1025–1033.

Larson JL, Covey MK, Wirtz SE, *et al.* Cycle ergometer and inspiratory muscle training in chronic obstructive pulmonary disease. *Am J Respir Crit Care Med* 1999; 160: 500–507.

Preusser BA, Winningham ML, Clanton TL. High- *vs* low-intensity inspiratory muscle interval training in patients with COPD. *Chest* 1994; 106: 110–117.

Romer LM, McConnell AK, Jones DA. Effects of inspiratory muscle training upon time trial performance in trained cyclists. *J Sports Sci* 20: 547–562, 2002.

Smith K, Cook D, Guyatt GH, Madhavan J, Oxman AD. Respiratory muscle training in chronic airflow limitation: a meta-analysis. *Am Rev Respir Dis* 1992; 145: 533–539.

Lötters F, van Tol TB, Kwakkel G, Gosselink R. Effects of controlled inspiratory muscle training in patients with COPD: a meta-analysis. *Eur Respir J* 20: 570–576, 2002.

J Appl Physiol. 2010 Aug;109(2):457-68. Epub 2010 May 27.

Inspiratory muscle training enhances pulmonary O(2) uptake kinetics and high-intensity exercise tolerance in humans.

Bailey SJ, Romer LM, Kelly J, Wilkerson DP, DiMenna FJ, Jones AM.

Resistenza

Threshold ± resistenza

Iperventilazione isocapnica ± resistenza

Allenamento dei muscoli respiratori in atleti

Nonostante un forte razionale teorico in favore dell' IMT pochi studi hanno indagato i meccanismi per un possibile effetto ergogenico

Bailey SG, Romer JL et Al J Appl Physiol (May 27, 2010) ; 10, 1152

Disegno: 16 soggetti fisicamente attivi, sottoposti a esercizio moderato intenso e massimale, randomizzati in IMT e controllo : sono misurati MIP, lattati, percezione di dispnea e fatica , **dinamica e cinetica VO2**

Risultato: ↑ la forza inspiratoria, ↓ la fatica dei RM, ↑ la prestazione e la tolleranza allo sforzo ↑ **dinamiche e cinetiche del VO2 durante sforzo massimale**

Meccanismi ipotizzati: ↓ fatica dei muscoli respiratori ↓ metaboriflesso ↑ la disponibilità e l'utilizzo di O2 nei muscoli periferici

16 atleti allenati
prestazione su 20 e 40 Km
RIMT aumenta la prestazione riduce la fatica dei MR

Romer LM Med Sci Sport Exerc 2002; 34 (5):785
Romer LM J Sports Sci 2002; 20:547

15 atleti di elite allenati
dopo EIMT controllo MIP e VO2
EIMT aumenta le MIP ma non il VO2.
nessuna correlazione tra MIP e VO2

Klusiewicz A. J Sport Phys Fitness 2008; 48:279

9 atleti agonisti altamente allenati - EIMT + RIMT
prestazione (3 test) e VO2
nessuna differenza tra allenati e placebo

Sonetti DA Respir Physiol 2001; 127:85

Kilding AE et Al Eur J Appl Physiol 2010; 108: 505

16 atleti randomizzati in un gruppo IMT e uno di controllo

IMT con dispositivo di resistenza / threshold

misura della prestazione, dei lattati
della percezione dello sforzo e delle PFR/MIP respiratorie

migliorano le prestazioni sui100 e 200 metri non sui 400, non cambiano le altre variabili tranne..

NB: miglioramento significativo delle MIP

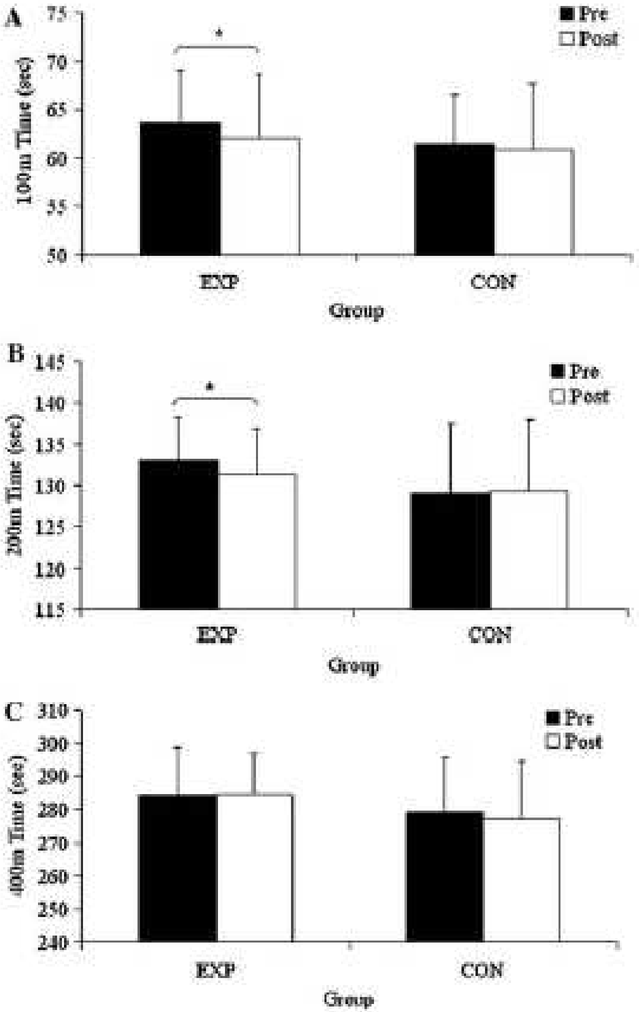
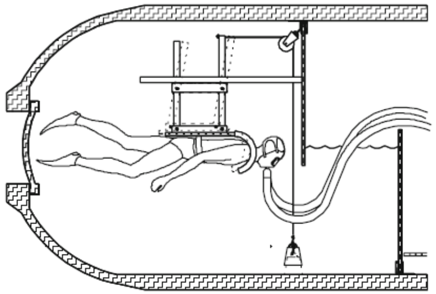


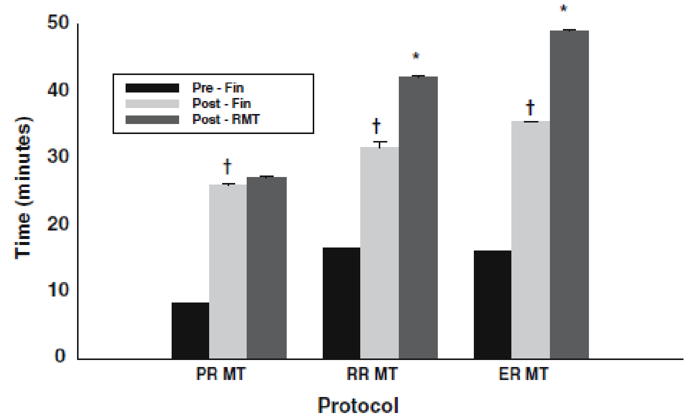
Fig. 1 Pre- and post-performance times for three competitive swimming distances: a 100 m; b 200 m; and c 400 m for both experimental and control groups. *Pre–post comparison, $P \leq 0.05$

Wylegala JA et Al Eur J Appl Physiol 2007; 99: 393



Ray AD – Ludgren CEG Eur J Appl Physiol 2010; 108: 811
Ray AD – Ludgreen CEG Undersea Hyperb Med 2008; 35 (3):185

30 subacquei randomizzati
in P, ET e RT, tutti pre-allenati

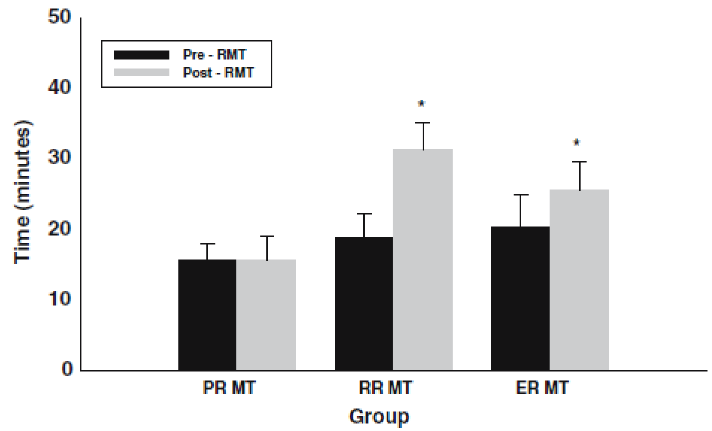


S swim

misura della prestazione e della funzione
in superficie S e in immersione UW (4 ft)

migliorano ET e RT, ET > RT in S
RT > ET in UW. Si riduce il VO2

lo stesso gruppo nel 2010 conferma
i risultati per RT e dimostra una riduzione
del WOB



UW swim

NB: miglioramento significativo delle MIP solo con RT

Exercise-induced respiratory muscle fatigue: implications for performance

Lee M. Romer[1] and Michael I. Polkey[2]

[1]*Centre for Sports Medicine and Human Performance, Brunel University, Uxbridge; and* [2]*Respiratory Muscle Laboratory, Royal Brompton Hospital, and National Heart and Lung Institute, London, United Kingdom*

J Appl Physiol 104: 879–888, 2008.

Studies that have specifically trained the respiratory muscles have reported either an improvement (16, 17, 28, 33, 78, 84, 119, 124, 131) or no change (25, 29, 38, 57, 92, 117, 140) in whole body exercise tolerance. A concern with all of these studies, however, is that endurance performance was evaluated using fixed work-rate tasks sustained to the limit of tolerance. Such tests do not accurately represent competitive endurance performance and are often unreliable (50).

More recent studies have used reliable and externally valid outcome measures (i.e., simulated time-trial performance) in conjunction with a placebo-controlled experimental design, and most (46, 55, 104, 137), but not all (117), findings from such studies indicate that respiratory muscle training has a small but likely significant effect on endurance exercise performance.

Further studies are needed!

Dati non conclusivi

ET probabilmente > RT

Razionale: ridurre la fatica?

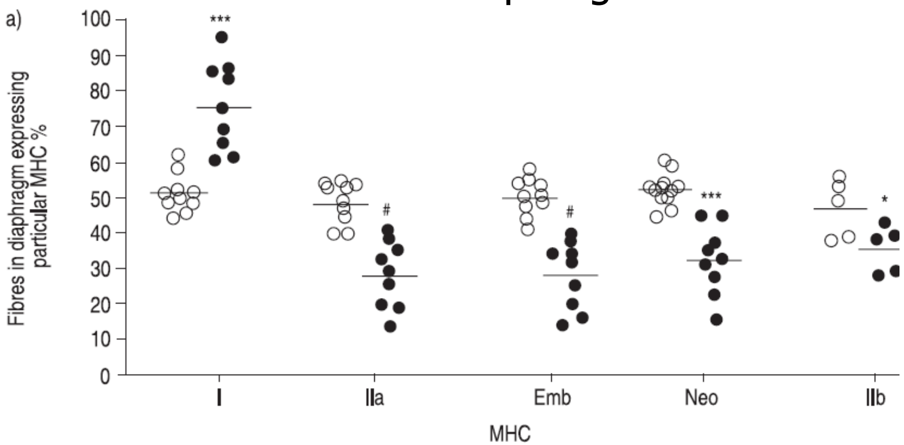
Ambienti speciali???

Allenamento dei muscoli respiratori nella BPCO

Il razionale teorico è più controverso.

Nella BPCO è evidente uno squilibrio tra aumento del carico e capacità meccanica e funzionale da parte dei MR: gli adattamenti sono variabili

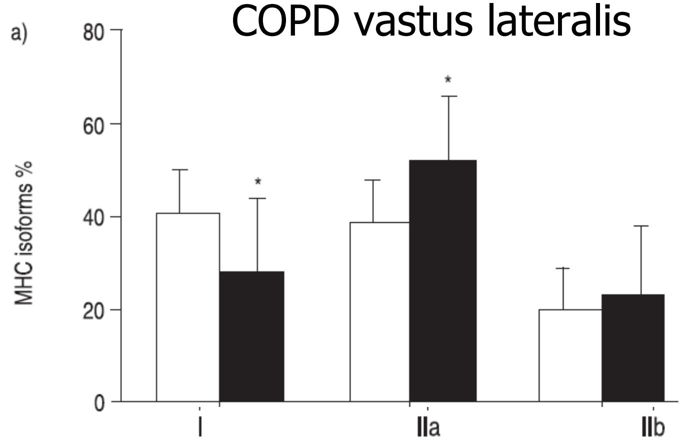
COPD diaphragm



○ Control

● COPD

COPD vastus lateralis



Control

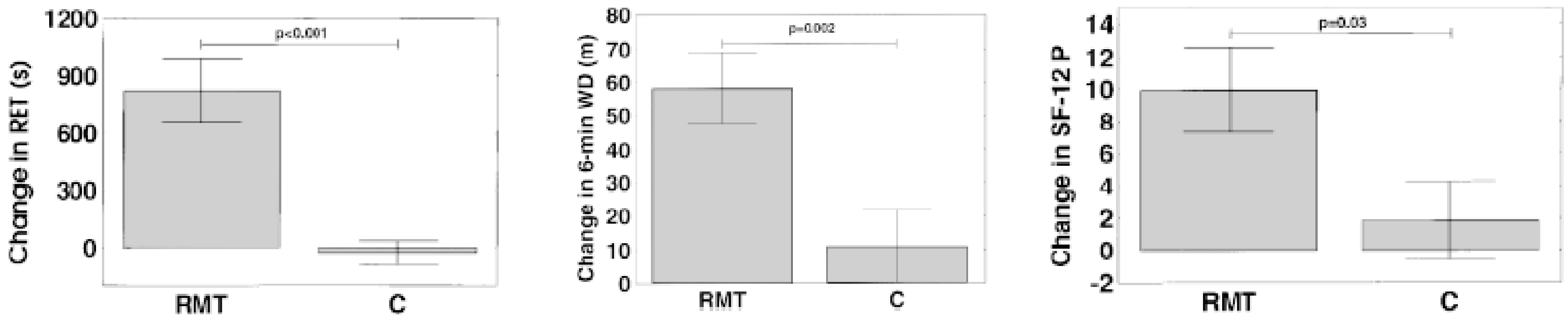
COPD

EUROPEAN RESPIRATORY monograph
CLINICAL HANDBOOKS FOR THE RESPIRATORY PROFESSIONAL

G. Gayan-Ramirez - Decramer Eur Respir Mon, 2006, 38, 201

Sherer TA et Al Am J Respir Crit Care Med 2000;162:1709

15 soggetti allenati con RMET (iperventilazione isocapnica) e 15 controlli con spirometria incentiva



In summary, the results of the present study show that respiratory muscle endurance training with normocapnic hyperpnea improves respiratory muscle and exercise performance, health-related quality of life, and dyspnea. The new portable training device used in the study makes home-based endurance training with normocapnic hyperpnea feasible, and allows its widespread application.

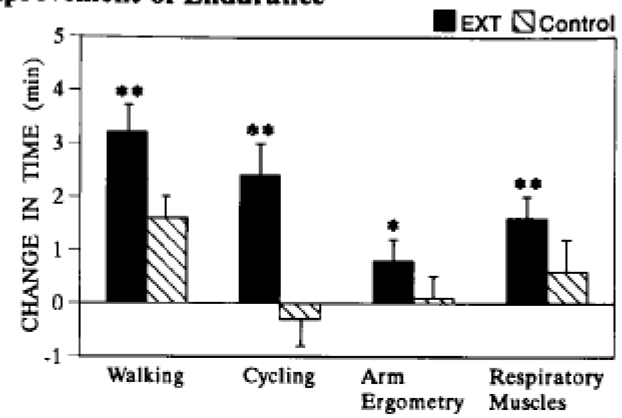
General Exercise Training Improves Ventilatory and Peripheral Muscle Strength and Endurance in Chronic Airflow Limitation

DENIS E. O'DONNELL, MAUREEN McGUIRE, LORELEI SAMIS, and KATHERINE A. WEBB

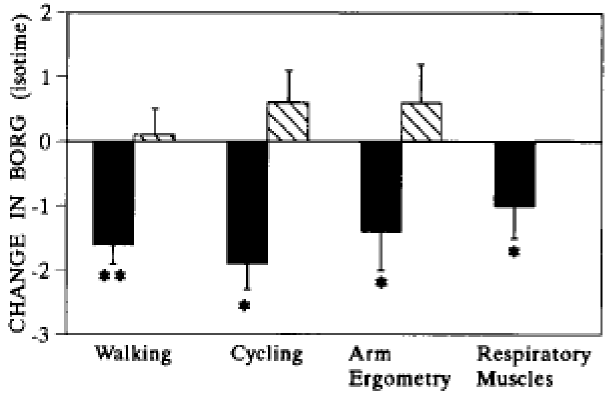
Respiratory Investigation Unit, Department of Medicine, Queen's University and Department of Physiotherapy, St. Mary's of the Lake Hospital, Kingston, Ontario, Canada

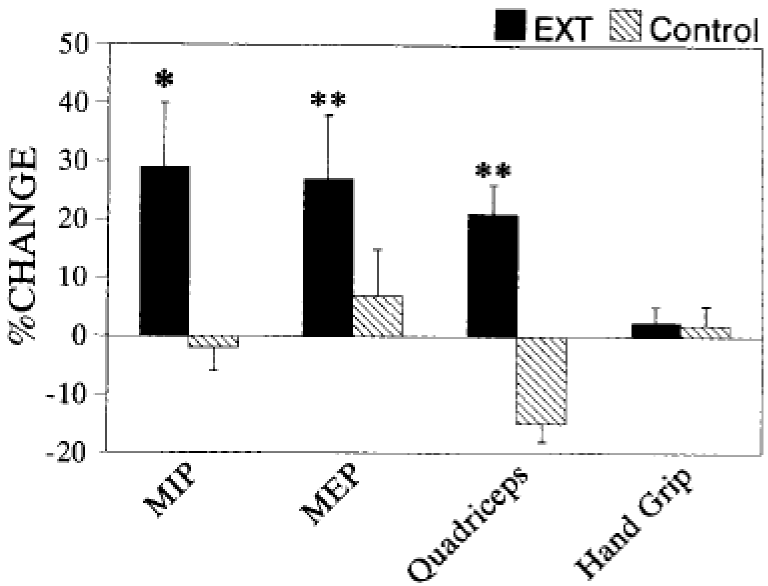
AM J RESPIR CRIT CARE MED 1998;157:1489.

Improvement of Endurance



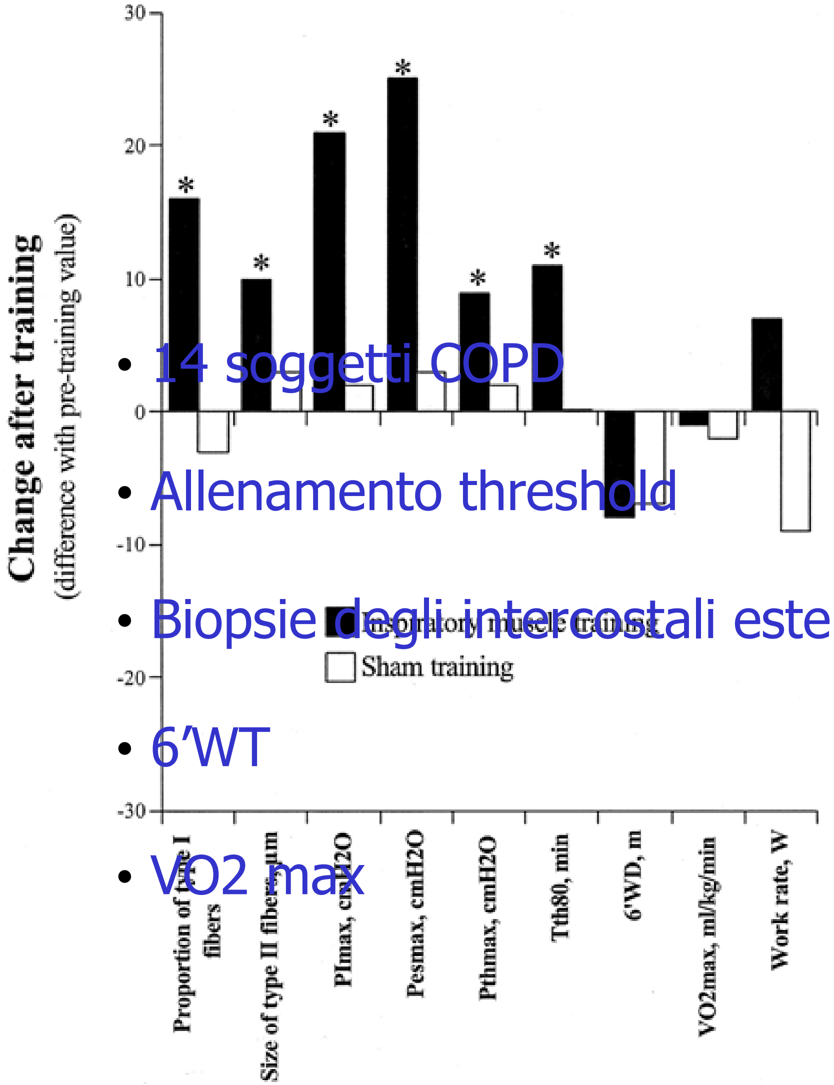
Reduction of Breathlessness





Ramirez-Sarmiento A et Al, Am J Respir Crit Care Med 2002 ;166:1491

- 14 soggetti COPD
- Allenamento threshold
- Biopsie degli intercostali esterni
- 6'WT
- VO2 max



Smith K, Cook D, Guyatt GH, Madhavan J, Oxman AD. Respiratory muscle training in chronic airflow limitation: a meta-analysis. *Am Rev Respir Dis* 145: 533–539, 1992.

Nessun effetto significativo su MIP, resistenza RM, capacità di esercizio, capacità funzionale

Sono stati inclusi 73 studi senza tenere conto del controllo del carico e tipo di allenamento

Lötters F, van Tol TB, Kwakkel G, Gosselink R. Effects of controlled inspiratory muscle training in patients with COPD: a meta-analysis. *Eur Respir J* 20: 570–576, 2002.

Table 2. – Overall results of the meta-analysis using the fixed effect model

Outcome measure	Studies n	Weighted averaged effect-size	Natural units	95% CI	Z-statistic	Homogeneity Q-statistic	Studies needed# n
Inspiratory muscle strength $P_{I,max}$	15	0.56	10.5 cmH_2O	0.35–0.77	5.27*	16.83	⩾77
Inspiratory muscle endurance MVV	4	0.21	2.8 $L \cdot min^{-1}$	-0.29–0.70	0.82	1.38	
Inspiratory muscle endurance s	7	0.41	154.2 s	0.14–0.68	2.94**	6.67	⩾14
Inspiratory muscle endurance cmH_2O	4	1.16	10.3 cmH_2O	0.67–0.15	4.67*	5.39	⩾10
Functional exercise capacity 6- or 12MWD	8	0.22	48.1 m	-0.05–0.48	1.58	2.58	
Laboratory exercise capacity $V'_{O_2,max}$	5	0.04	-0.04 $L \cdot min^{-1}$	-0.36–0.29	-0.24	2.50	
Laboratory Exercise capacity $V'_{E,max}$	5	0.03	-1.5 $L \cdot min^{-1}$	-0.03–0.35	0.16	5.49	
Dyspnea-Borg exercise-related	5	-0.55	-1.5	-0.90–0.19	-3.10**	3.69	⩾10
Dyspnoea-TDI rest	2	2.3	2.7	1.44–3.15	5.28**	4.14	⩾14

CI: confidence interval; $P_{I,max}$: maximum static inspiratory alveolar pressure; MVV: maximal voluntary ventilation; 6- or 12MWD: 6- or 12-min walking distance; $V'_{O_2,max}$: maximal oxygen consumption; $V'_{E,max}$: maximal minute ventilation; TDI: transitional dyspnoea index. #: studies needed for p>0.05; **: p<0.01; ***: p<0.001.

Lötters F, van Tol TB, Kwakkel G, Gosselink R. Effects of controlled inspiratory muscle training in patients with COPD: a meta-analysis. *Eur Respir J* 20: 570–576, 2002.

Table 3. – Subgroup analysis of general exercise reconditioning plus inspiratory muscle training *versus* general exercise reconditioning alone using the fixed-effect model

Outcome measure	Studies n	Weighted averaged effect-size	Natural units	95% CI	Z-statistic	Homogeneity Q-statistic
Inspiratory muscle strength $P_{I,max}$	6	0.47	6.7 cmH_2O	0.15–0.79	2.88**	13.28*
Inspiratory muscle endurance MVV	2	-0.03	-0.95 $L \cdot min^{-1}$	-0.77–0.72	-0.07	0.14
Inspiratory muscle endurance in s	3	0.55	164.4 s	0.14–0.97	2.61**	0.09
Functional exercise capacity 6- or 12MWD	4	0.20	54 m	-0.21–0.61	0.95	0.79
Laboratory exercise capacity $V'_{O_2,max}$	3	-0.17	-0.01 $L \cdot min^{-1}$	-0.69–0.35	-0.63	0.16
Laboratory exercise capacity $V'_{E,max}$	3	-0.10	1.2 $L \cdot min^{-1}$	-0.61–0.42	-0.38	0.01

CI: confidence interval; $P_{I,max}$: maximum static inspiratory alveolar pressure; MVV: maximal voluntary ventilation; 6- or 12MWD: 6- or 12-min walking distance; $V'_{O_2,max}$: maximal oxygen consumption; $V'_{E,max}$: maximal minute ventilation. *: $p<0.05$; **: $p<0.01$.

Lötters F, van Tol TB, Kwakkel G, Gosselink R. Effects of controlled inspiratory muscle training in patients with COPD: a meta-analysis. *Eur Respir J* 20: 570–576, 2002.

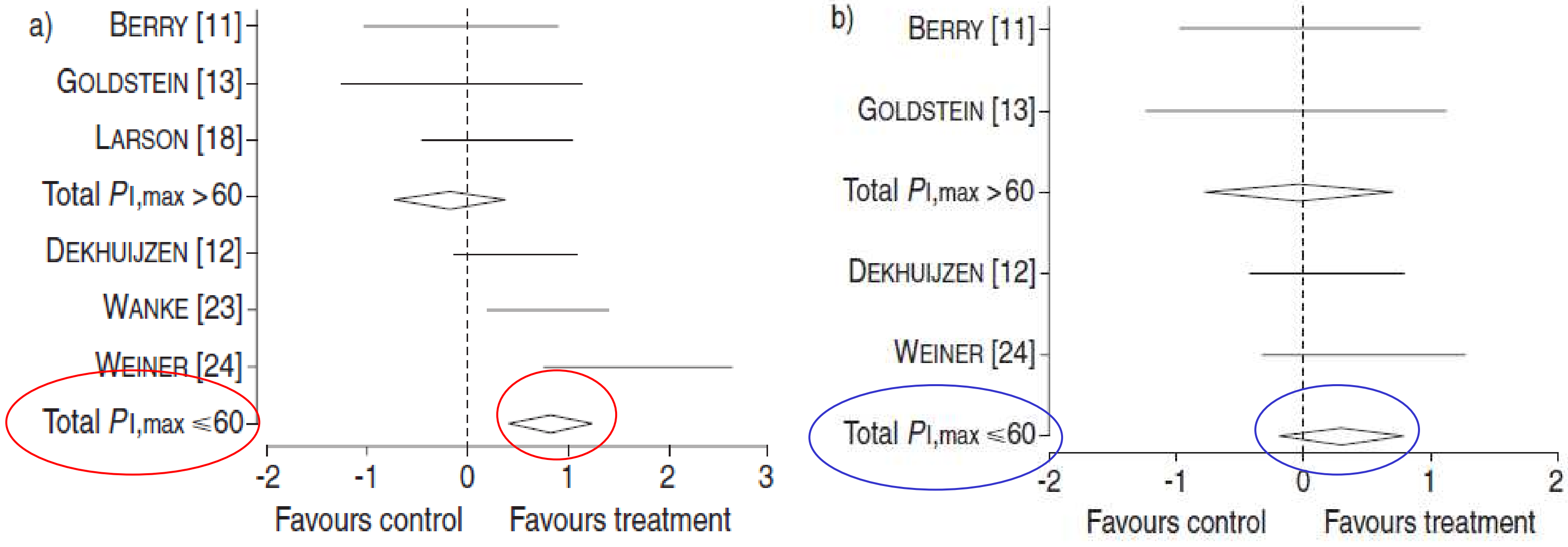


Fig. 1. – Weighted summary effect-sizes of a) inspiratory muscle strength and b) functional exercise capacity (SD units) for the studies with general exercise reconditioning plus inspiratory muscle training.

J Appl Physiol 107: 971–976, 2009.
First published April 2, 2009; doi:10.1152/japplphysiol.91459.2008.

Review

Response of the respiratory muscles to rehabilitation in COPD

Marc Decramer
Respiratory Division, University Hospital, University of Leuven, Belgium

SUMMARY

The role of IMT in respiratory rehabilitation remains controversial. This is particularly due to the absence of clear data on the effects of IMT on outcomes in patients with COPD, such as exercise capacity, functional exercise capacity, and dyspnea during activities of daily living. Large, randomized studies properly designed methodologically are unfortunately not available. It would be particularly important to demonstrate that the addition of IMT to general exercise training would result in greater benefits than exercise training alone. This has not been done convincingly thus far. Future studies would also need to be directed toward patients who are more likely to benefit from IMT, such as patients with low inspiratory muscle force.

American Thoracic Society/European Respiratory Society Statement on Pulmonary Rehabilitation

Am J Respir Crit Care Med Vol 173. pp 1390–1413, 2006

Adding inspiratory muscle training to standard exercise training in patients **with poor initial inspiratory muscle strength** has been shown in some studies to improve exercise capacity more than exercise training alone. In patients with less respiratory muscle weakness, evidence for the addition of inspiratory muscle training to regular exercise training is lacking.

Three types of inspiratory muscle training have been reported:

inspiratory resistive training, threshold loading and normocapnic hyperpnea.

At present, there are **no data to support one method over the other.**

Linda Nici, Claudio Donner, Emiel Wouters, Richard Zuwallack, Nicolino Ambrosino, Jean Bourbeau, Mauro Carone, Bartolome Celli, Marielle Engelen, Bonnie Fahy, Chris Garvey, Roger Goldstein, Rik Gosselink, Suzanne Lareau, Neil MacIntyre, Francois Maltais, Mike Morgan, Denis O'Donnell, Christian Prefault, Jane Reardon, Carolyn Rochester, Annemie Schols, Sally Singh, and Thierry Troosters, on behalf of the ATS/ERS Pulmonary Rehabilitation Writing Committee

CHEST Supplement
PULMONARY REHABILITATION: JOINT ACCP/AACVPR EVIDENCE-BASED CLINICAL PRACTICE GUIDELINES

Pulmonary Rehabilitation*

Joint ACCP/AACVPR Evidence-Based Clinical Practice Guidelines

Andrew L. Ries, Gerene S. Bauldoff, Brian W. Carlin, Richard Casaburi, Charles F. Emery, Donald A. Mahler, Barry Make, Carolyn L. Rochester, Richard ZuWallack and Carla Herrerias

Chest 2007;131;4-42

16. The scientific evidence does not support the routine use of inspiratory muscle training as an essential component of pulmonary rehabilitation.
Grade of Recommendation: 1B

BPCO: some underlying questions

Il lavoro ventilatorio è cronicamente aumentato:
i m.r. sono già allenati?

I m.r. sono in situazione meccanica sfavorevole
L'allenamento è applicabile?

I programmi di R.P. comprendono allenamento muscolare
L'allenamento sistemico migliora anche i m.r.?

I muscoli respiratori:allenamento?

altre patologie

- Obesità
- Stroke
- SLA
- CHF
- lesioni spinali (SCI)
- malattie neuromuscolari
- pre post chirurgia toracica - cardiochirurgia

debole o nessuna evidenza

Scano G. et Al Respir Med. 2009 Sep;103(9):1276

Sheel AW et Al J Spinal Cord Med. 2008;31(5):500

Reid WD et Al Clin Rehabil. 2008 ;22(10-11):1003

Padula CA Res Theory Nurs Pract. 2007;21(2):98

Esperienza personale

CHI

- BPCO: non ipercapnia, non ipercapnia da sforzo, MIP < 60%
- Post chirurgia toracica con segni clinici e/o Rx di ipofunzione RM
- Sindrome obesità - ipoventilazione dopo test iperventilazione

COME

- Dispositivi RT (threshold) con pressione 30% di MIP
- Iperventilazione isocapnica in casi selezionati - giovani non BPCO
- Raramente IMT associato ad allenamento sistemico, possibile alternanza o interval training in PZ BPCO

Grazie per l’attenzione