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POWERbreathe & IMT Related Research

CLINICAL APPLICATIONS OF IMT

In this section you will find links to research papers that report the findings of clinical trials of IMT and studies of the effect of certain medical conditions upon the strength and function of the inspiratory muscles. The latter provides the rationale for IMT.

We have only included research that is published in peer-reviewed, high-quality scientific journals. As well as original studies, we have also included some articles that review IMT; these have been written by experts in this field of research.

To help you find what you are looking for, we have provided the title of each research paper to give a flavour of its content, and each title is linked to a full copy of the paper, or its abstract.

Studies showing that IMT is helpful:

- "The Effects of 1 Year of Specific Inspiratory Muscle Training in Patients With COPD." http://www.chestjournal.org/cgi/content/abstract/128/5/3177
- "Ventilatory muscle training improves exercise capacity in chronic obstructive pulmonary disease patients." http://www.ncbi.nlm.nih.gov/pubmed/7362134
- "Targeted resistive ventilatory muscle training in chronic obstructive pulmonary disease." http://jap.physiology.org/cgi/content/abstract/65/6/2726
- "Resistive breathing training in patients with chronic obstructive pulmonary disease." http://www.chestjournal.org/cgi/content/abstract/90/5/662?ck=nck
- "High-intensity inspiratory muscle training in patients with chronic obstructive pulmonary disease and severely reduced function." http://www.jcrjournal.com/pt/re/jcardiorehab/abstract.00008483-200107000-00008.htm;jsessionid=LGfJX37McjZH6l2vjgphL6NFvpMkTCQfG5YkH71f8w51KyLTYD9L!-1990489359!181195628!8091!-1

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- "Training of inspiratory muscles in chronic obstructive lung disease. Its impact on functional changes and exercise tolerance." http://www.ncbi.nlm.nih.gov/pubmed/9557177

- "Targeted inspiratory muscle training improves respiratory muscle function and reduces dyspnea in patients with chronic obstructive pulmonary disease." http://www.ncbi.nlm.nih.gov/pubmed/2742247

- "Nocturnal saturation improves by target-flow inspiratory muscle training in patients with COPD." http://ajrccm.atsjournals.org/cgi/content/abstract/153/1/260

- "High-intensity inspiratory muscle training in COPD." http://www.erj.ersjournals.com/cgi/content/abstract/27/6/1119

- "Inspiratory muscle training in patients with chronic obstructive pulmonary disease." http://www.ncbi.nlm.nih.gov/pubmed/8247819

- "Inspiratory muscle training in pulmonary rehabilitation program in COPD patients." Link to: http://www.resmedjournal.com/article/S0954-6111(07)00013-3/abstract

- "Inspiratory muscle training protocol using a pressure threshold device: effect on dyspnea in chronic obstructive pulmonary disease." http://www.ncbi.nlm.nih.gov/pubmed/9915380

- "Inspiratory muscle training in patients with chronic obstructive pulmonary disease: structural adaptation and physiologic outcomes." http://ajrccm.atsjournals.org/cgi/content/abstract/166/11/1491

- "Inspiratory muscle training in patients with COPD: effect on dyspnea, exercise performance, and quality of life." http://www.chestjournal.org/cgi/content/abstract/120/3/748

- "Effect of inspiratory muscle training on muscle strength and quality of life in patients with chronic airflow limitation: a randomized controlled trial." http://www.ncbi.nlm.nih.gov/pubmed/16324598

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- "Increased exercise performance in patients with severe COPD following inspiratory resistive training." http://www.chestjournal.org/cgi/content/abstract/81/4/436

- "Feasibility of High-Intensity, Interval-Based Respiratory Muscle Training in COPD." http://www.chestjournal.org/cgi/content/abstract/123/1/142

- "Effect of inspiratory muscle training with an intermediate load on inspiratory power output in COPD." http://www.erj.ersjournals.com/cgi/content/abstract/11/1/28

- "Effects of combined inspiratory muscle and cycle ergometer training on exercise performance in patients with COPD." http://erj.ersjournals.com/cgi/content/abstract/7/12/2205

- "Inspiratory muscle training combined with general exercise reconditioning in patients with COPD." http://www.chestjournal.org/cgi/content/abstract/102/5/1351

- "Maintenance of inspiratory muscle training in COPD patients: one year follow-up." http://www.erj.ersjournals.com/cgi/content/abstract/23/1/61

- "The cumulative effect of long-acting bronchodilators, exercise, and inspiratory muscle training on the perception of dyspnea in patients with advanced COPD." http://www.chestjournal.org/cgi/content/abstract/118/3/672

- "Inspiratory Muscle Training May Increase Peak Inspiratory Flow in Chronic Obstructive Pulmonary Disease." http://content.karger.com/ProdukteDB/produkte.asp?Doi=88095

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Expert reviews of IMT:

- "Inspiratory muscle training: a way to breathe more easily." http://content.karger.com/ProdukteDB/produkte.asp?Doi=91529
- "Target-flow inspiratory muscle training during pulmonary rehabilitation in patients with COPD." http://www.chestjournal.org/cgi/content/abstract/99/1/128
- "Inspiratory muscle training in COPD patients." http://www.ncbi.nlm.nih.gov/pubmed/2679605
- "Effects of controlled inspiratory muscle training in patients with COPD: a meta-analysis." http://erj.ersjournals.com/cgi/content/abstract/20/3/570
- "What is the role of inspiratory muscle training in the treatment of chronic obstructive pulmonary disease?" http://www.ncbi.nlm.nih.gov/pubmed/16324596
- "Inspiratory muscle training: integrative review." http://www.ingentaconnect.com/content/springer/rtnp/2006/00000020/00000004/art00005
- "Respiratory muscle training in chronic obstructive pulmonary disease: inspiratory, expiratory, or both?" http://www.ncbi.nlm.nih.gov/pubmed/15699786
- "Inspiratory muscle training: a way to breathe more easily." http://content.karger.com/ProdukteDB/produkte.asp?Aktion=ShowPDF&ArtikelNr=91529&Ausgabe=231710&ProduktNr=224278&filename=91529.pdf

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Chronic Obstructive Pulmonary Disease (COPD)

Evidence that the condition of the inspiratory muscles is impaired:

- "Relationship of Upper-Limb and Thoracic Muscle Strength to 6-min Walk Distance in COPD Patients." http://www.chestjournal.org/cgi/content/abstract/129/3/551

- "Inspiratory muscle dysfunction and chronic hypercapnia in chronic obstructive pulmonary disease." http://www.ncbi.nlm.nih.gov/pubmed/2024841

- "Human diaphragm remodelling associated with chronic obstructive pulmonary disease: clinical implications." http://ajrccm.atsjournals.org/cgi/content/abstract/168/6/706

- "Effects of emphysema on diaphragm microvascular oxygen pressure." http://ajrccm.atsjournals.org/cgi/content/abstract/163/5/1081

- "The diaphragm in COPD. Better than expected, but not good enough." http://www.ncbi.nlm.nih.gov/pubmed/1881421

- "Peak inspiratory mouth pressure in healthy subjects and in patients with COPD." http://www.chestjournal.org/cgi/content/abstract/107/3/652

- "Diaphragm adaptations in patients with COPD." http://respiratory-research.com/content/9/1/12

- "Diaphragm muscle fiber dysfunction in chronic obstructive pulmonary disease: toward a pathophysiological concept." http://ajrccm.atsjournals.org/cgi/content/abstract/175/12/1233

- "Diaphragm dysfunction in chronic obstructive pulmonary disease." http://ajrccm.atsjournals.org/cgi/content/abstract/172/2/200

- "Steroid-induced myopathy and its significance to respiratory disease: a known disease rediscovered." http://www.erj.ersjournals.com/cgi/content/abstract/5/8/997

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- "Corticosteroid-induced myopathy of the respiratory muscles." http://www.ncbi.nlm.nih.gov/pubmed/7969664

- "Distribution of muscle weakness in patients with stable chronic obstructive pulmonary disease." http://www.jcrjournal.com/pt/re/jcardiorehab/abstract.00008483-200011000-00004.htm;jsessionid=LGcfFYyx4qJDrkk2HCnQLnhv21qTHWK3MNrdTJcW0k10bHhghSZG!-1990489359!181195628!8091!-1

Asthma

Studies showing that IMT is helpful:

- "Inspiratory muscle training improves lung function and reduces exertional dyspnoea in mild/moderate asthmatics." McConnell, A. K., M. P. Caine, et al. (1998). "Inspiratory muscle training improves lung function and reduces exertional dyspnoea in mild/moderate asthmatics." Clinical Science 95(2): 4P.

- "Inspiratory muscle training in patients with bronchial asthma." http://www.chestjournal.org/cgi/content/abstract/102/5/1357

- "Specific inspiratory muscle training in patients with mild asthma with high consumption of inhaled beta(2)-agonists." http://www.chestjournal.org/cgi/content/abstract/117/3/722?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&author1=Weiner%2C+P&searchid=1&FIRSTINDEX=0&sortspec=relevance&volume=117&resourcetype=HWCIT

- "Influence of gender and inspiratory muscle training on the perception of dyspnea in patients with asthma." http://www.chestjournal.org/cgi/content/abstract/122/1/197?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&author1=Weiner%2C+P&andorexactfulltext=and&searchid=1&FIRSTINDEX=0&sortspec=relevance&volume=122&resourcetype=HWCIT

- "The relationship among inspiratory muscle strength, the perception of dyspnea and inhaled beta2-agonist use in patients with asthma." http://www.pulsus.com/journals/abstract.jsp?origPg=abstract.jsp&sCurrPg=abstract&jnlKy=4&atlKy=4242&isuKy=335&isArt=t&&HCtype=Consumer

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Cystic Fibrosis

Studies showing that IMT is helpful:

- "The effects of inspiratory muscle training in patients with cystic fibrosis." http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed&uid=7149451&cmd=showdetailview&indexed=google

- "Inspiratory muscle training in patients with cystic fibrosis." http://www.resmedjournal.com/article/S0954-6111(00)90966-1/abstract

- "Inspiratory Muscle Training Improves Lung Function and Exercise Capacity in Adults With Cystic Fibrosis." http://www.chestjournal.org/cgi/content/abstract/126/2/405

- "Ventilatory muscle endurance training in normal subjects and patients with cystic fibrosis." http://www.ncbi.nlm.nih.gov/pubmed/921061

- "Improved pulmonary function and exercise tolerance with inspiratory muscle conditioning in children with cystic fibrosis." http://www.chestjournal.org/cgi/content/abstract/104/5/1490

- "Benefit of selective respiratory muscle training on exercise capacity in patients with chronic congestive heart failure." http://www.circ.ahajournals.org/cgi/content/abstract/91/2/320

Chronic heart failure and heart disease

Evidence that the condition of the inspiratory muscles is impaired:

- "Inspiratory muscle strength is a determinant of maximum oxygen consumption in chronic heart failure." http://heart.bmjjournals.com/cgi/content/abstract/74/4/381

- "The oxygen cost of breathing in patients with cardiorespiratory disease." http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed&uid=7091914&cmd=showdetailview&indexed=google

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- "Muscle strength, symptom intensity, and exercise capacity in patients with cardiorespiratory disorders."
  http://ajrccm.atsjournals.org/cgi/content/abstract/152/6/2021

- "Inspiratory muscle relaxation rate slows during exhaustive treadmill walking in patients with chronic heart failure."
  http://ajrccm.atsjournals.org/cgi/content/abstract/163/6/1400

- "Respiratory muscle dysfunction in congestive heart failure: clinical correlation and prognostic significance."
  http://circ.ahajournals.org/cgi/content/abstract/103/17/2153?ck=nck

Studies showing that IMT is helpful:

- "Inspiratory muscle training improves blood flow to resting and exercising limbs in patients with chronic heart failure."
  http://content.onlinejacc.org/cgi/content/short/51/17/1663?rss=1

- "Inspiratory muscle training in patients with chronic heart failure awaiting cardiac transplantation: results of a pilot clinical trial."
  http://www.ptjournal.org/cgi/reprint/77/8/830.pdf

- "Inspiratory muscle training in patients with heart failure and inspiratory muscle weakness: a randomized trial."
  http://www.ncbi.nlm.nih.gov/pubmed/16487841

- "Effects of resistive breathing on exercise capacity and diaphragm function in patients with ischaemic heart disease."
  http://www.escardiocontent.org/periodicals/heafai/article/S1388-9842(99)00027-6/abstract

- "Inspiratory muscle training using an incremental endurance test alleviates dyspnea and improves functional status in patients with chronic heart failure."
  http://www.ejcpr-selection.com/pt/re/esc/abstract.00149831-200412000-00008.htm;jsessionid=LLfPwHTRJkc6sHT3HZDJLn5JCMJmCG36h6Dz1RQLmLhNthQpfjb7!774718804!181195629!8091!-1

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- "Selective training of respiratory muscles in patients with chronic heart failure." http://www.ncbi.nlm.nih.gov/pubmed/11351463

- "Effect of specific inspiratory muscle training on dyspnea and exercise tolerance in congestive heart failure." http://www.ncbi.nlm.nih.gov/pubmed/10955110

Miscellaneous medical conditions

Studies showing that IMT is helpful:

- "Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial." http://jama.ama-assn.org/cgi/content/abstract/296/15/1851

- "Feasibility of preoperative inspiratory muscle training in patients undergoing coronary artery bypass surgery with a high risk of postoperative pulmonary complications: a randomized controlled pilot study." http://intl-cre.sagepub.com/cgi/content/abstract/20/11/949

- "Prophylactic inspiratory muscle training in patients undergoing coronary artery bypass graft." http://www.springerlink.com/content/tyv4dvva3t210ugd/

- "Respiratory Muscle Training in Restrictive Thoracic Disease: A Randomized Controlled Trial." http://www.ncbi.nlm.nih.gov/pubmed/17141634

- "Exercise and respiratory training improve exercise capacity and quality of life in patients with severe chronic pulmonary hypertension." http://circ.ahajournals.org/cgi/content/abstract/CIRCULATIONAHA.106.618397v1

- "Inspiratory Muscle Training: A Simple, Cost-effective Treatment for Inspiratory Stridor." http://bjsm.bmj.com/cgi/content/abstract/41/10/694

- "Inspiratory Muscle Training in Exercise-Induced Paradoxical Vocal Fold Motion." http://www.ac.wwu.edu/~csd/sdarticle.pdf

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- "Inspiratory muscle strength training with behavioral therapy in a case of a rower with presumed exercise-induced paradoxical vocal-fold dysfunction." http://www.ijporlonline.com/article/S0165-5876(04)00108-9/abstract

- "Dose-dependent effect of individualized respiratory muscle training in children with Duchenne muscular dystrophy." http://www.nmd-journal.com/article/S0960-8966(02)00005-6/abstract

- "Inspiratory muscle training in patients with Duchenne muscular dystrophy." http://www.chestjournal.org/cgi/reprint/105/2/475.pdf?ck=nck

- "2 Years' experience with inspiratory muscle training in patients with neuromuscular disorders." http://www.chestjournal.org/cgi/content/abstract/120/3/765

- "Inspiratory muscle resistive training in respiratory failure." http://www.ncbi.nlm.nih.gov/pubmed/3883864

- "Inspiratory muscle training and the perception of dyspnea in Parkinson's disease." http://cjns.metapress.com/app/home/contribution.asp?referrer=parent&backto=issue,11,22;journal,18,55;linkingpublicationresults,1:300307,1

- "Respiratory training for a person with C3-C4 tetraplegia." http://www.physiotherapy.asn.au/ajp/vol_45/4/AustJPhysiotherv45i4Ehrlich.pdf

- "Resistive inspiratory muscle training: its effectiveness in patients with acute complete cervical cord injury." http://www.archives-pmr.org/article/S0003-9993(00)90106-0/abstract

- "Training of the respiratory muscles in individuals with tetraplegia." http://www.nature.com/sc/journal/v37/n8/abs/3100887a.html

- "Resistive inspiratory muscle training in sleep-disordered breathing of traumatic tetraplegia." http://www.archives-pmr.org/article/S0003-9993(02)04653-1/abstract

- "Effects of 8-Week, Interval-Based Inspiratory Muscle Training and Breathing Retraining in Patients With Generalized Myasthenia Gravis." http://www.chestjournal.org/cgi/content/abstract/128/3/1524

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- "Respiratory muscle training in patients with moderate to severe myasthenia gravis." http://www.ncbi.nlm.nih.gov/pubmed/9706726
- "Inspiratory muscle training in patients with prior polio who use part- time assisted ventilation." http://www.ncbi.nlm.nih.gov/pubmed/10943756
- "Exercise training and inspiratory muscle training in patients with bronchiectasis." http://thorax.bmj.com/cgi/content/abstract/60/11/943
- "Inspiratory muscle training during treatment with corticosteroids in humans." http://www.chestjournal.org/cgi/content/abstract/107/4/1041
- "Specific inspiratory muscle training in chronic hemodialysis." http://www.ncbi.nlm.nih.gov/sites/entrez?db=pubmed&uid=8846980&cmd=showdetailview&indexed=google
- "Effects of Inspiratory Muscle Training on Exercise Capacity and Spontaneous Physical Activity in Elderly Subjects: a Randomized Controlled Pilot Trial." http://www.thieme-connect.com/ejournals/abstract/sportsmed/doi/10.1055/s-2007-965077

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IMT, WARM-UP & COOL-DOWN IN SPORTS & EXERCISE

In this section you will find links to research papers that report the findings of research studies of IMT, as well as inspiratory muscle warm-up and cool-down.

We have only included research that is published in peer-reviewed, high-quality scientific journals. As well as original studies, we have also included some articles that review IMT; these have been written by experts in this field of research.

To help you find what you are looking for, we have provided the title of each research paper to give a flavour of its content, and each title is linked to a full copy of the paper, or its abstract.

Inspiratory muscle training

Rowing:

- "Inspiratory muscle training improves rowing performance." http://www.acsm-msse.org/pt/re/msse/abstract.00005768-200105000-00020.htm;jsessionid=LVLpXL6kJhS1n4BnWPfJYTQyMLF8yFQFG8yysBh922LMmqVDphxy!150813252!181195629!8091!-1

- "The influence of inspiratory and expiratory muscle training upon rowing performance." http://www.springerlink.com/content/k3154g28nkm03w40/

Cycling:

- "Effects of inspiratory muscle training upon time trial performance in trained cyclists." http://www.thieme-connect.de/ejournals/abstract/sportsmed/doi/10.1055/s-2008-1025647

- "Inspiratory muscle fatigue in trained cyclists: effects of inspiratory muscle training." http://www.acsm-msse.org/pt/re/msse/abstract.00005768-200205000-00010.htm;jsessionid=LVTL1SKGxm1pmw7b699Gy1YV2p9sJvyj1qL47pRSWvQgHCDtXvDw!1167962659!181195628!8091!-1

- "Inspiratory muscle training improves cycling time-trial performance and anaerobic work capacity but not critical power." http://www.springerlink.com/content/l9085718p7045216/

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- "Effect of high-intensity inspiratory muscle training on lung volumes, diaphragm thickness, and exercise capacity in subjects who are healthy." http://ptjournal.org/cgi/content/abstract/86/3/345

- "The effects of different inspiratory muscle training intensities on exercising heart rate and perceived exertion." http://www.ingentaconnect.com/content/klu/421/2004/00000092/F0020001/art00008

- "Inspiratory resistive loading improves cycling capacity: a placebo controlled trial." http://bjsm.bmj.com/cgi/content/abstract/38/6/730

- "Effects of Inspiratory Muscle Training on Whole Body Exercise Performance in Males."

Running:

- "Oxygen uptake kinetics and maximal aerobic power are unaffected by inspiratory muscle training in healthy subjects where time to exhaustion is extended." http://www.springerlink.com/content/e7ybq3dmxpcbnwxd/

- "Inspiratory muscle training improves shuttle run performance in healthy subjects." http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B7CVK-4HBB7HC-6&_user=10&_coverDate=12%2F31%2F1999&_alid=731263558&_rdoc=6&_fmt=high&_orig=search&_cdi=18081&_sort=d&_docanchor=&view=c&_ct=268&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=f1225f55fa940676c236cb5e60f4fcde

- "Concurrent inspiratory muscle and cardiovascular training differentially improves both perceptions of effort and 5000-m running performance compared to cardiovascular training alone." http://bjsm.bmj.com/cgi/content/abstract/bjsm.2007.045377v2

Team Sports:

- "Effects of inspiratory muscle training upon recovery time during high intensity, repetitive sprint activity." http://www.ncbi.nlm.nih.gov/pubmed/12165887

Swimming:

- "Respiratory muscle training improves swimming endurance in divers." http://www.springerlink.com/content/djg6876j76ml9561/

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- "Resistive respiratory muscle training improves and maintains endurance swimming performance in divers." http://www.ncbi.nlm.nih.gov/pubmed/17672173

High Altitude:

- "Effects of inspiratory muscle training on exercise responses in normoxia and hypoxia." http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6X16-4KY88PB-1&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=fba63105e000e3dbe0be17df337b79e8

- "High-Altitude Exposure Reduces Inspiratory Muscle Strength." http://www.thieme-connect.com/ejournals/abstract/sportsmed/doi/10.1055/s-2006-924367;jsessionid=0674355CA78F97DCE72DEB21821293F6.jvm5

Warm-up and cool-down

- "Specific respiratory warm-up improves rowing performance and exertional dyspnoea." http://www.acsm-msse.org/pt/re/msse/abstract.00005768-200107000-00017.htm;jsessionid=LVbfnCn9Q4svsXX1XQYsnlsGBpgSny2TvnmGyHJmSgJP4PQGPVBm!1167962659!181195628!8091!-1

- "Effect of specific inspiratory muscle warm-up on intense intermittent run to exhaustion." http://www.springerlink.com/content/9031370152040277/

- "Specific inspiratory muscle warm-up enhances badminton footwork performance." http://rparticle.web-p.cisti.nrc.ca/rparticle/AbstractTemplateServlet?journal=apnm&volume=32&year=&issue=&msno=h07-077&calyLang=eng

- "Blood lactate during recovery from intense exercise: impact of inspiratory loading." http://www.acsm-msse.org/pt/re/msse/abstract.00005768-200801000-00016.htm;jsessionid=LVpHSDHSP8yLnwBnrV1N85zQZjR9G3rh4pTTJmwWK21NJTQyLjWD!1167962659!181195628!8091!-1

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Exercise-induced inspiratory muscle fatigue

- "Inspiratory muscle fatigue in swimmers after a single 200 m swim." http://www.ingentaconnect.com/content/tandf/rjsp/2003/00000021/00000008/art00008

- "Inspiratory muscle fatigue in trained cyclists: effects of inspiratory muscle training." http://www.acsm-msse.org/pt/re/msse/abstract.00005768-200205000-00010.htm;jsessionid=LVfcmh0J1B2ZQ2GXlPkpvVVJmQGvfRNVkRJmmtpJGVV1BH5QyLlG!1167962659!181195628!8091!-1

- "Inspiratory muscle training improves rowing performance." http://www.acsm-msse.org/pt/re/msse/abstract.00005768-200105000-00020.htm;jsessionid=LVfYpRh866nnJhv1VZt6VT948HFvSmZ91ykyhXHl23jwDF6vsQnh!1167962659!181195628!8091!-1

- "Influence of environmental temperature on exercise-induced inspiratory muscle fatigue." http://www.springerlink.com/content/g5r20bpx46qgdf52/

- "Aerobic fitness effects on exercise-induced low-frequency diaphragm fatigue." http://jap.physiology.org/cgi/content/abstract/81/5/2156

- "Exercise-induced diaphragmatic fatigue in healthy humans." http://jp.physoc.org/cgi/content/abstract/460/1/385

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