Dyspnea...

Mechanisms

Assessment

Management

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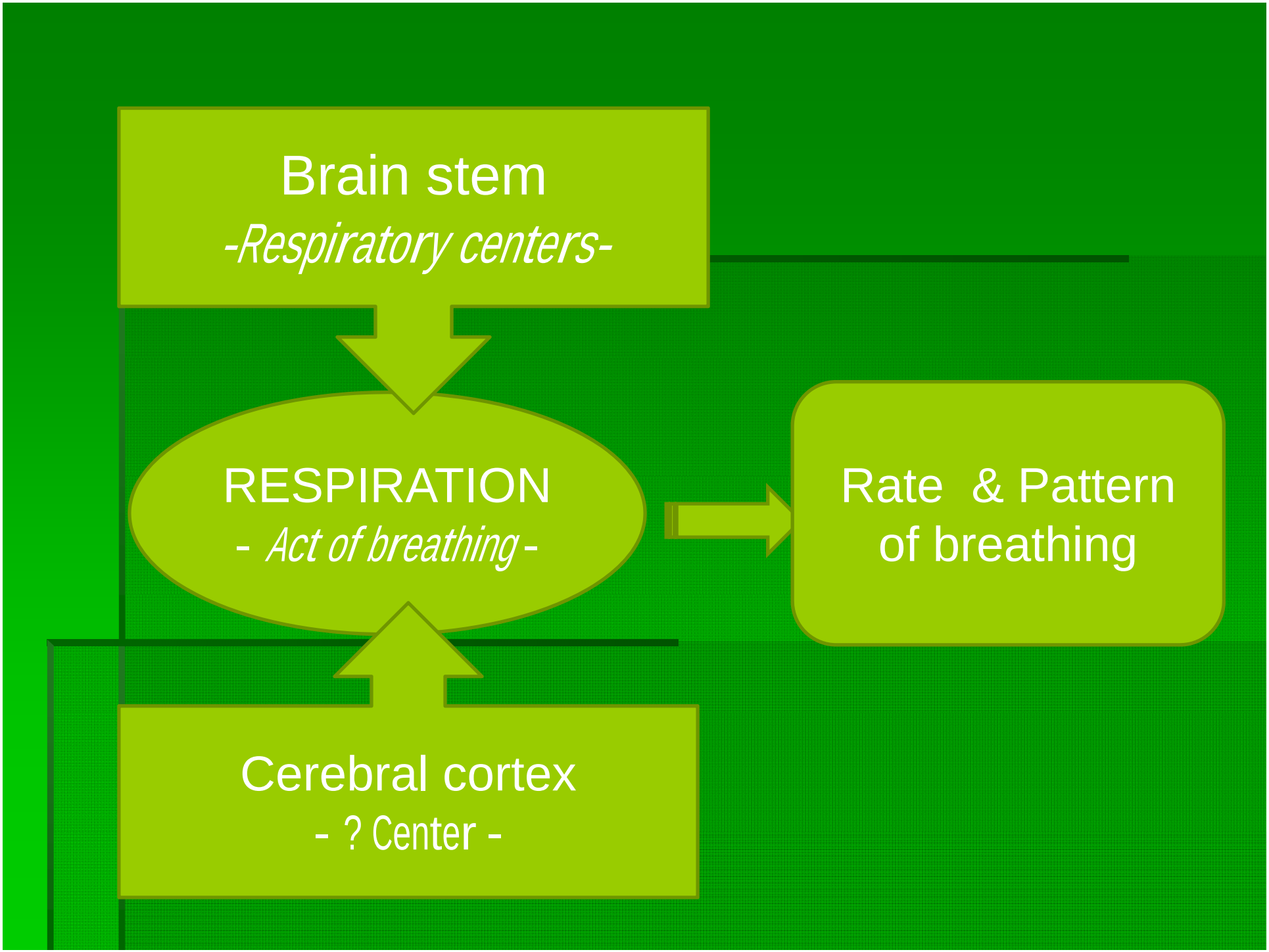

Brain stem
-Respiratory centers-
RESPIRATION
- Act of breathing -
Rate & Pattern of breathing
Cerebral cortex
- ? Center -

Dyspnea

- Greek: *dys*, meaning painful, difficult, and *pneuma*, meaning breath
- Protective function
- Symptom with suffering and disability
- Cardinal symptom of both cardiopulmonary disorder
- Relief of dyspnea → improve QoL

Definitions of dyspnea:

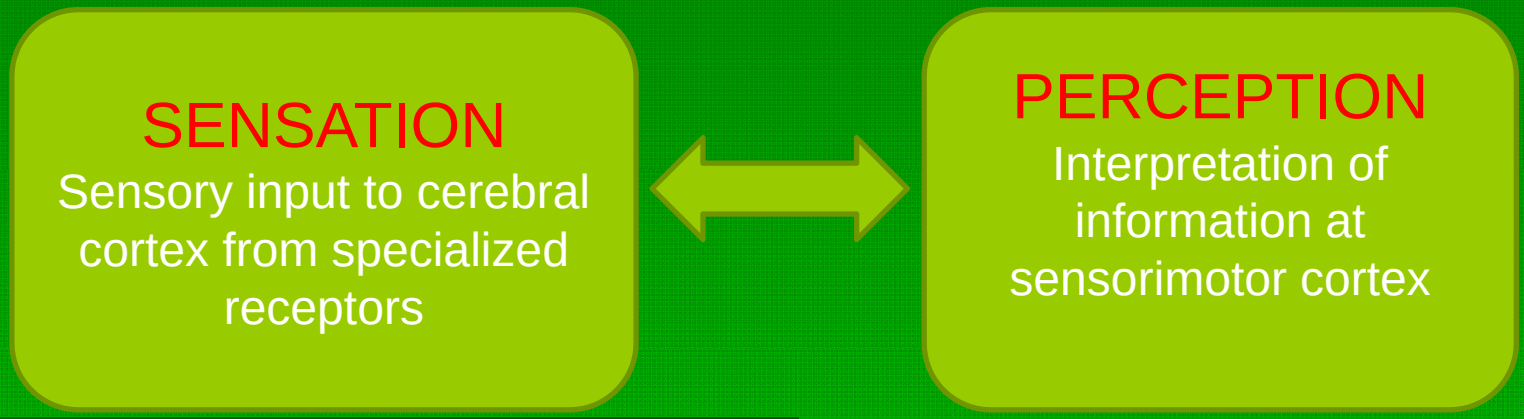
- “difficult, labored, uncomfortable breathing”
- “awareness of respiratory distress”
- “the sensation of feeling breathless or experiencing air hunger”
- “an uncomfortable sensation of breathing”

Wide range of meanings:

1. Subjective complaint without consistency in objective signs such as tachypnea
2. Interpretations represent extrapolations from normal breathlessness (e.g., after strenuous exercise)
3. Most experimental observations relating to dyspnea are based on study of normal subjects or animals under artificial circumstances
4. Loosely applied term, based on experience with predominant patient population (e.g., patients with COPD or asthma)

- Despite this variability, in clinical medicine, the complaint of dyspnea almost invariably implies respiratory discomfort.

Dyspnea→amalgam of two components



- The American Thoracic Society (1999) defines *dyspnea* as a
  - subjective experience of breathing discomfort that consists of qualitatively distinct sensation that vary in intensity
  - The experience derives from interactions among multiple physiological, psychological, social, and environmental factors, and may induce secondary physiological and behavioral responses

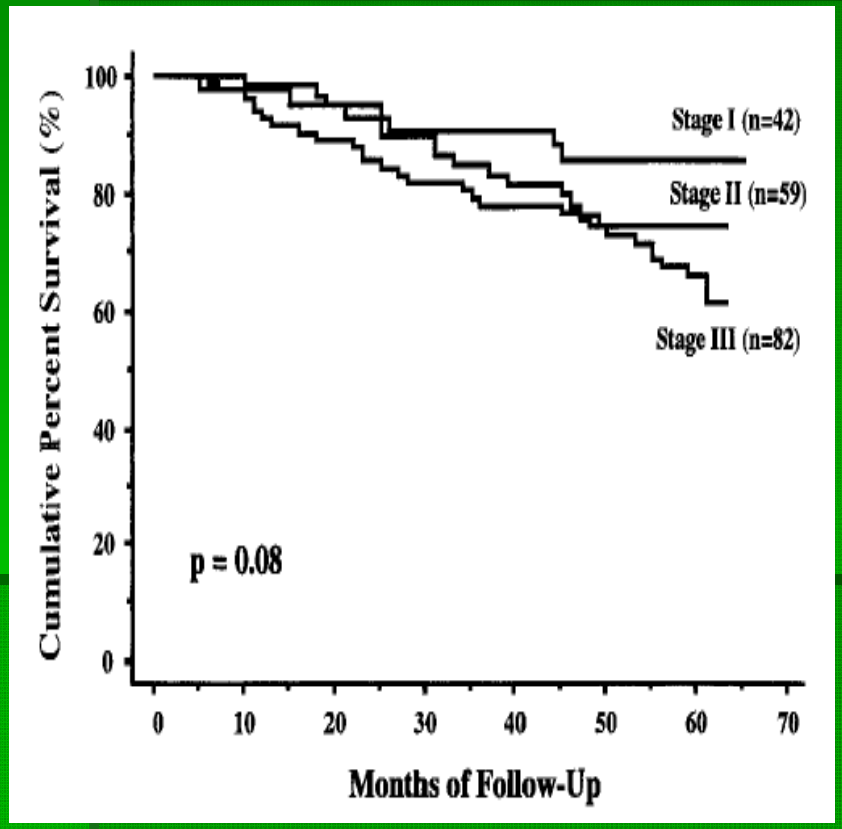
Am J Respir Crit Care Med Vol 159. pp 321–340, 1999

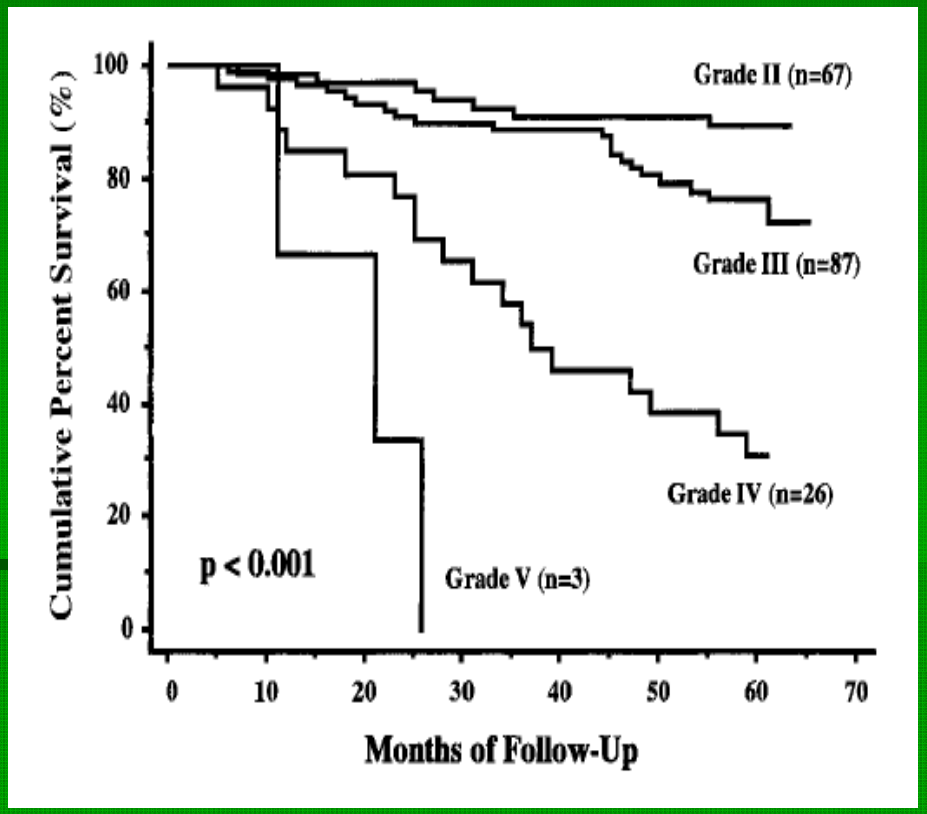
Dyspnea: Clinical Problem

- Common in patients with cardiac or respiratory disease as well as in healthy individuals who are obese and/or deconditioned
- Prevalence of dyspnea in healthy adults (< 65 yrs) ranges from 10 -18%
- >30% of elderly individuals (≥ 65 years of age) report breathlessness with activities of daily living, including walking on a level surface or up an incline
- Independent predictor of mortality even after adjusting for age, sex, smoking history, and prior occupation*

**Eur J Epidemiol* 2001; 17:223-229

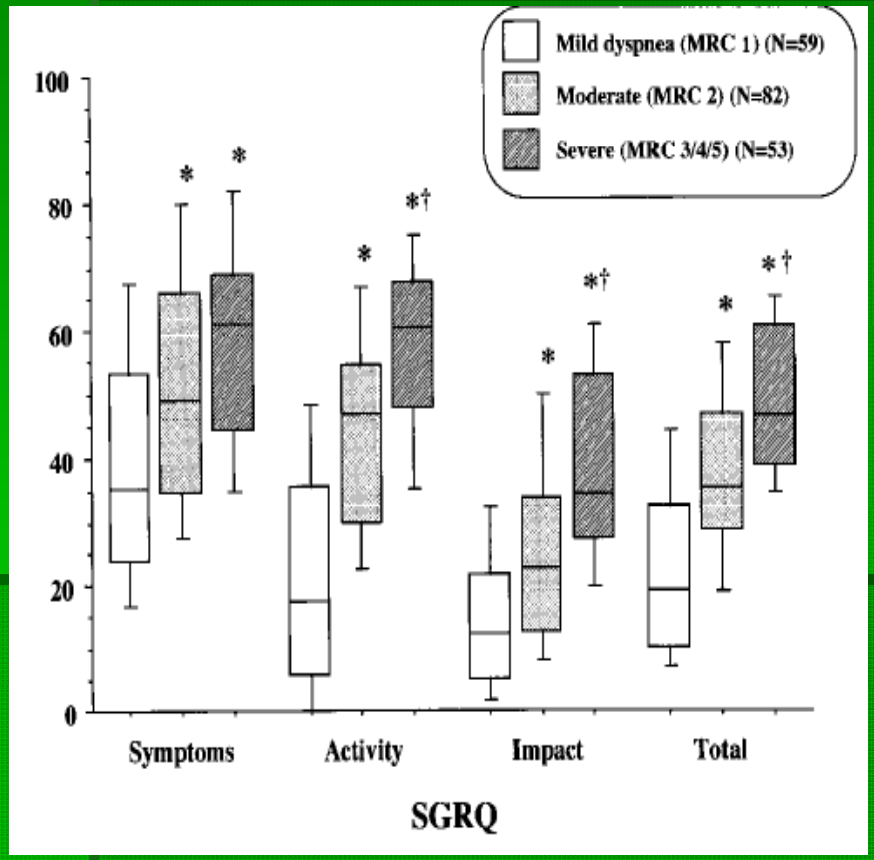
Dyspnea Is a Better Predictor of 5-Year Survival Than Airway Obstruction in Patients With COPD

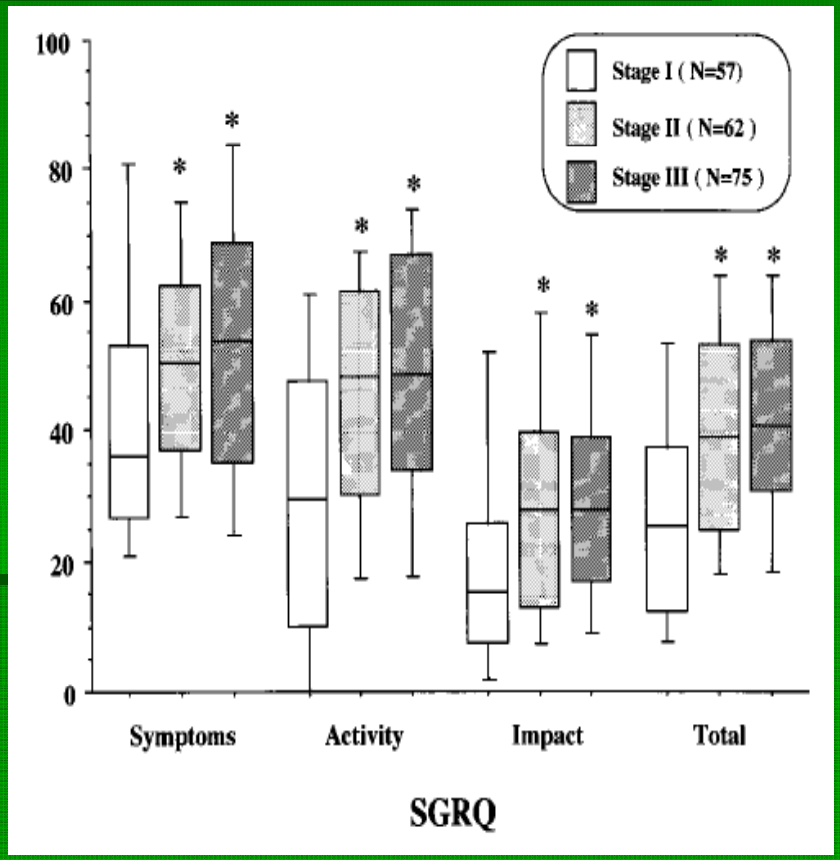




CHEST 2002; 121:1434–1440

A Comparison of the Level of Dyspnea vs Disease Severity in Indicating the Health-Related Quality of Life of Patients With COPD





CHEST 1999; 116:1632–1637

Language of dyspnea

- Dyspnea – subjective sensation
- Cultural or language differences may result in patients using different words to describe the same sensory experience
- Sensation may differ depending on pathophysiology of dysnea

Example of a List of Descriptiors Utilized in Dyspnea Questionnaires

1. My breath does not go in all the way.
2. My breathing requires effort.
3. I feel that I am smothering.
4. I feel a hunger for more air.
5. My breathing is heavy.
6. I can not take a deep breath.
7. I feel out of breath.
8. My chest feels tight.
9. My breathing requires more work.
10. I feel that I am suffocating.
11. I feel that my breath stops.
12. I am gasping for breath.
13. My chest is constricted.
14. I feel that my breathing is rapid.
15. My breathing is shallow.
16. I feel that I am breathing more.
17. I can not get enough air.
18. My breath does not go out all the way.
19. My breathing requires more concentration.

Am Rev Respir Dis. 1990;142:1009-1014
Am Rev Respir Dis. 1991;144:826-832

Clusters of respiratory sensations described by normal subjects who experienced breathing discomfort in association with a range of respiratory tasks

Cluster	BrHo	CO_2	DTV	Res	Elas	FRC	VT	Exer
1. Rapid		X				X	X	X
2. Exhalation						X		
3. Concentration			X				X	
4. Shallow							X	
5. Work		X		X				
6. Suffocating								
7. Hunger	X		X	X	X			
8. Heavy								X
9. Gasping								

BrHo = breathholding
DTV = driven targeted ventilation
Elas = elastic load
VT = decreased tidal volume
CO2 = steady state hypercapnia
Res = resistive load
FRC = increased functional residual capacity
Exer = exercise

Am Rev Respir Dis. 1989;140:1021-1027

Respiratory Sensations Associated with Various Conditions

Sensation	COPD	Congestive Heart Failure	Interstitial Lung Disease	Asthma	Neuromuscular and Chest-Wall Disease	Pregnancy	Pulmonary Vascular Disease
Rapid breathing		X					X
Incomplete exhalation				X			
Shallow breathing				X	X		
Increased work or effort	X		X	X	X		
Feeling of suffocation	X	X					
Air hunger	X	X				X	
Chest tightness				X			
Heavy breathing				X			

Simon et al.Am Rev Respir Dis 1990;142:1009-14.
Elliot et al.Am Rev Respir Dis 1991;144:826-32

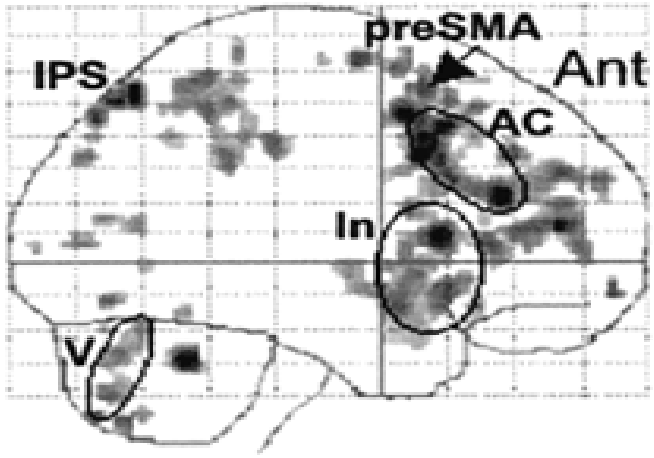
Cluster analysis

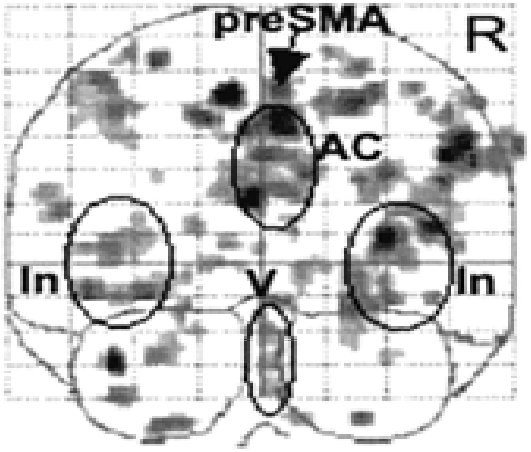
Descriptor	Condition
Chest Tightness	Asthma (Simon et al., 1990)
Inability to get a deep breath Unsatisfying Breath	COPD Hyperinflation (O'Donnell et al., 1997)
Air Hunger Urge to Breathe	Congestive heart failure COPD Asthma Neuromuscular weakness (Simon et al., 1990)
Heavy Breathing Breathing More	Peripheral muscle atrophy Cardiovascular deconditioning (Mahler et al., 1996)

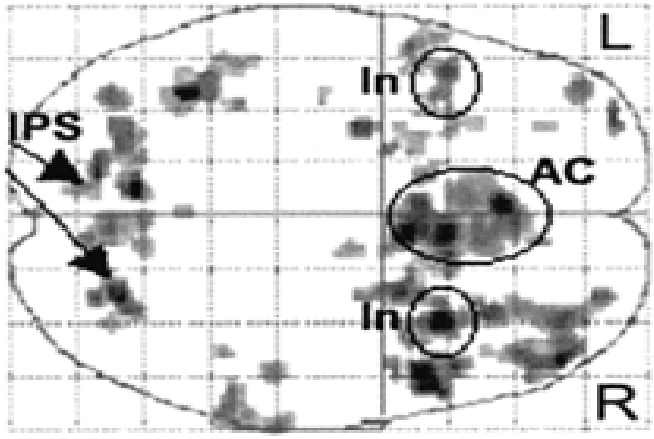
Problems in study of dyspnea

1. Neural pathways underlying it are not well understood
2. Region of cerebral cortex that processes information related to dyspnea remains unidentified
3. No area of cortex that when stimulated causes dyspnea or any other respiratory sensation, nor is there a cortical lesion that abolishes the sensation of dyspnea or the perception of other respiratory-related stimuli
4. Difficulty in defining the precise physical stimulus that causes it
5. Difficulty in extrapolating experimental studies

Statistical Map Showing Significant Regional Signal Increases Associated with Periods of Air Hunger in an Experiment in which Subjects Were Made Breathless with Acute Hypercapnia in the Setting of Restricted Tidal Volumes







AC = anterior cingulate

In = insula

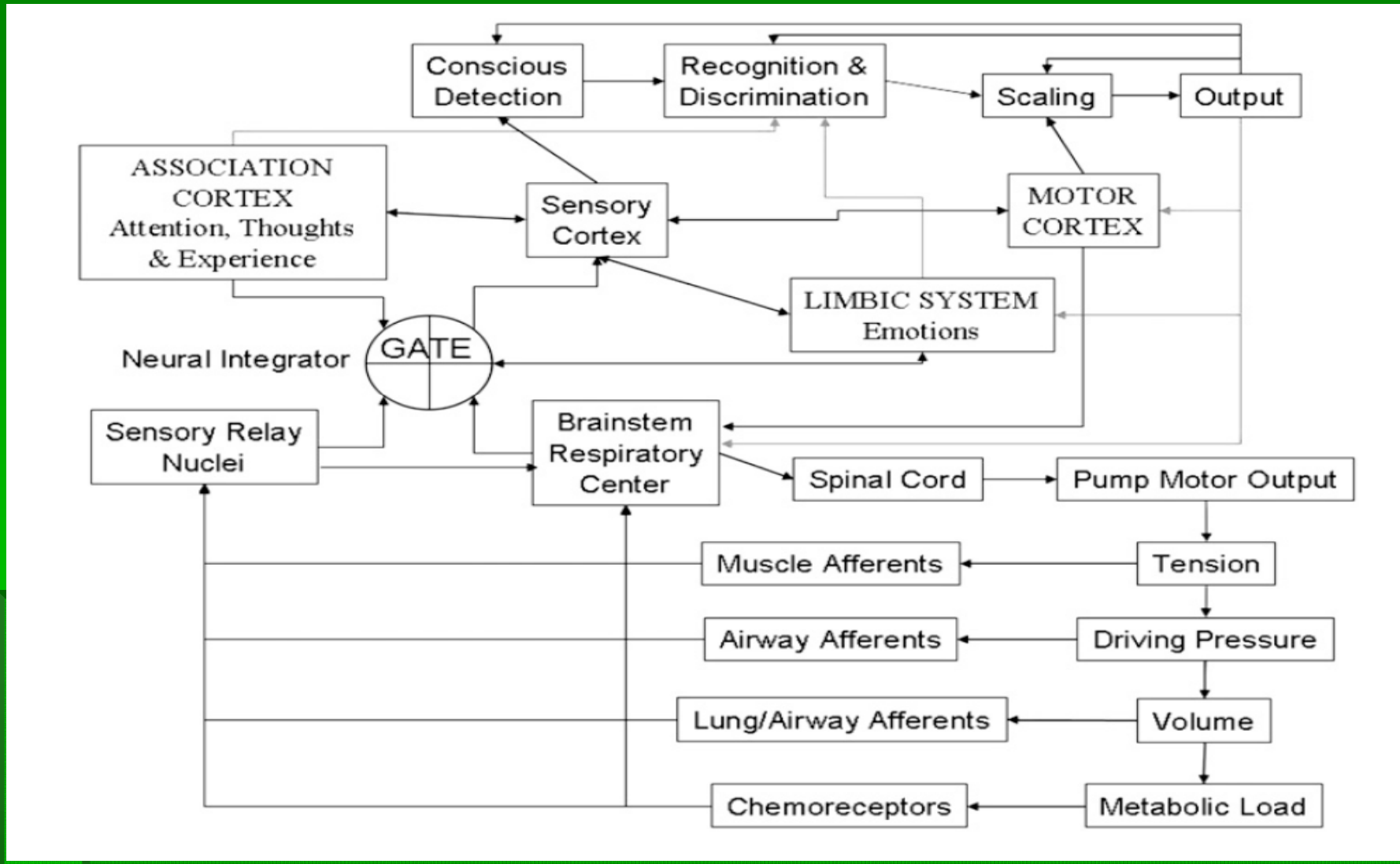
IPS = intraparietal sulcus

SMA = supplementary motor area

V = cerebellar vermis

J Neurophysiol. 2002; 88:1500-1511.

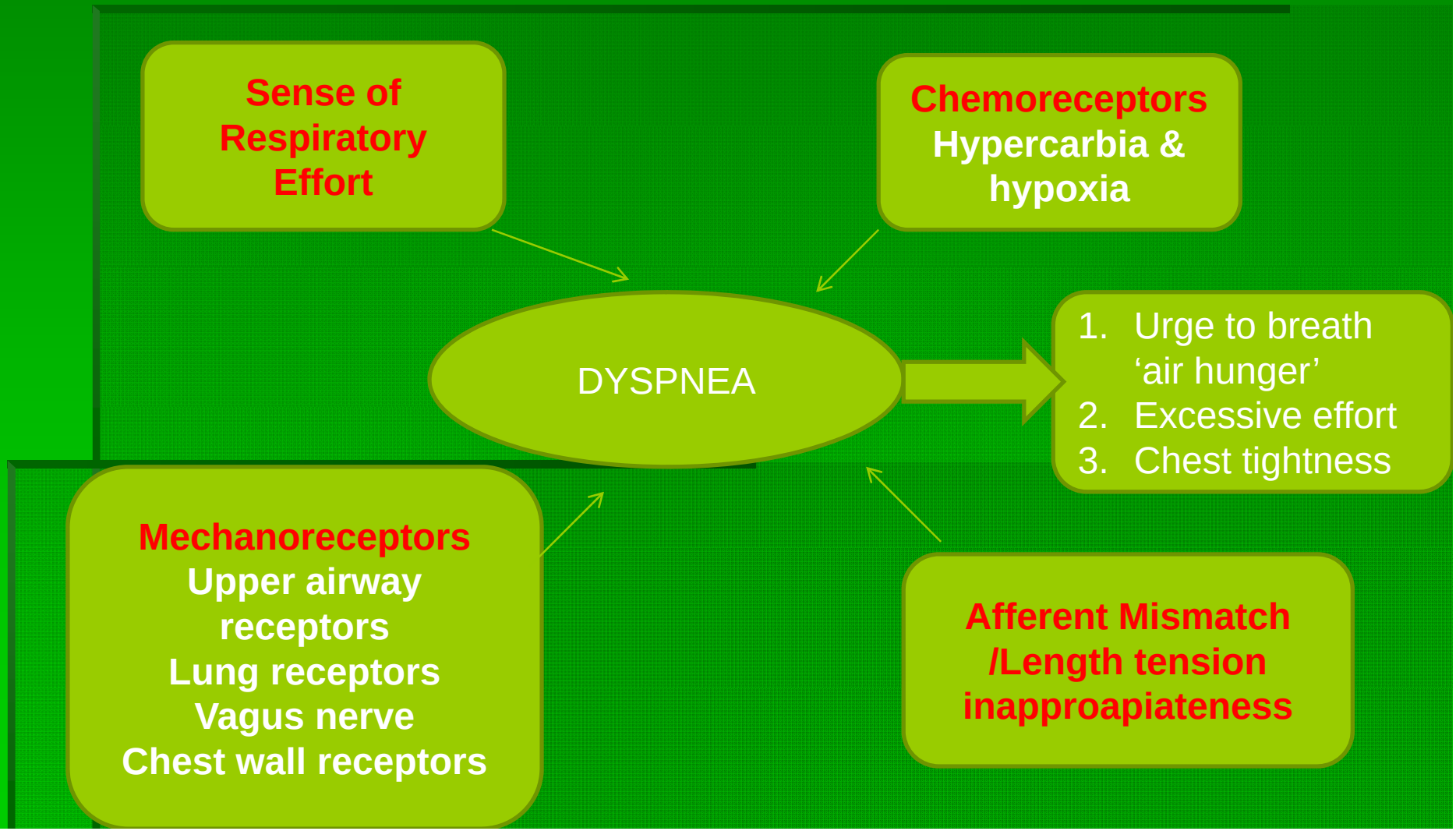
Respiratory sensory gating system model



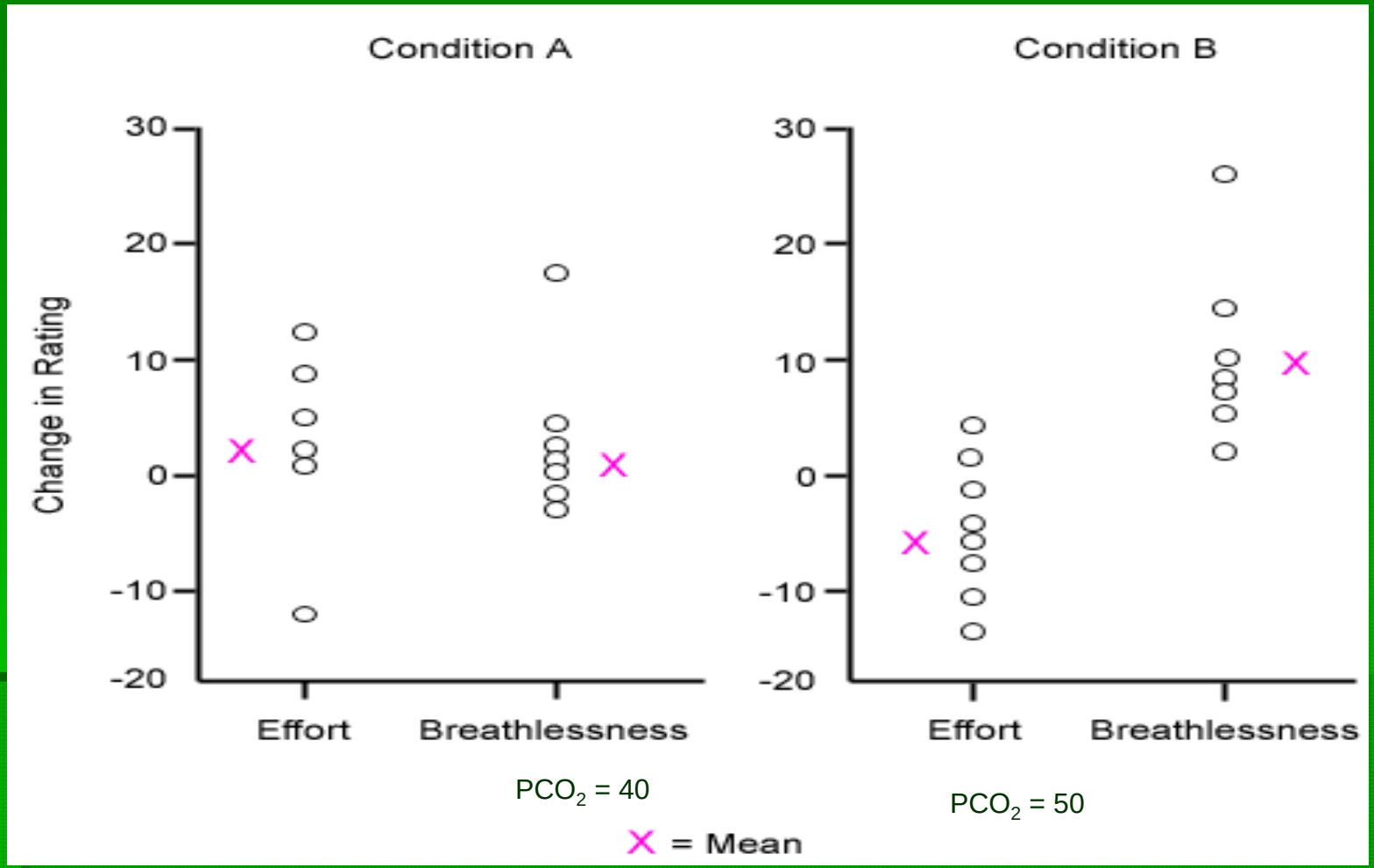
Proc Am Thorac Soc Vol 4. pp 145–168, 2007

Stimuli	Receptors	Locations	Clinical Conditions	Quality of Dyspnea
Chemoreceptors				
Changes in CSF pH	Central Chemoreceptors	Brain Stem (Medulla)		Air Hunger
Changes in pO_2, pCO_2	Peripheral Chemoreceptors	Carotid and Aortic bodies	CHF	
Mechanoreceptors				
Stretch Lung Inflation	Pulmonary Stretch Receptors	Pulmonary Alveoli		Chest Tightness Suffocation
Tactile Stimulation Air Flow Rate Bronchial Muscle tone	Pulmonary Irritant Receptors	Bronchial Epithelium	Asthma	
Pulmonary Interstitial & Capillary Pressure	C Fibers (J Æ Juxta capillary Receptors)	Interstitium Capillaries	CHF, COPD, Pulmonary Vascular Diseases e.g., PE	
Mechanical (movement, length & tension change)	Muscle Spindles	Intercostal Muscles	COPD, Asthma, ILD Neuromuscular diseases	Increased Sense of Effort
Mechanical (force of contraction)	Tendon Organs	Diaphragm		
Mechanical (chest wall movement & timing)	Proprioceptors	Joints and Tendons		

Physiologic correlate of dyspnea



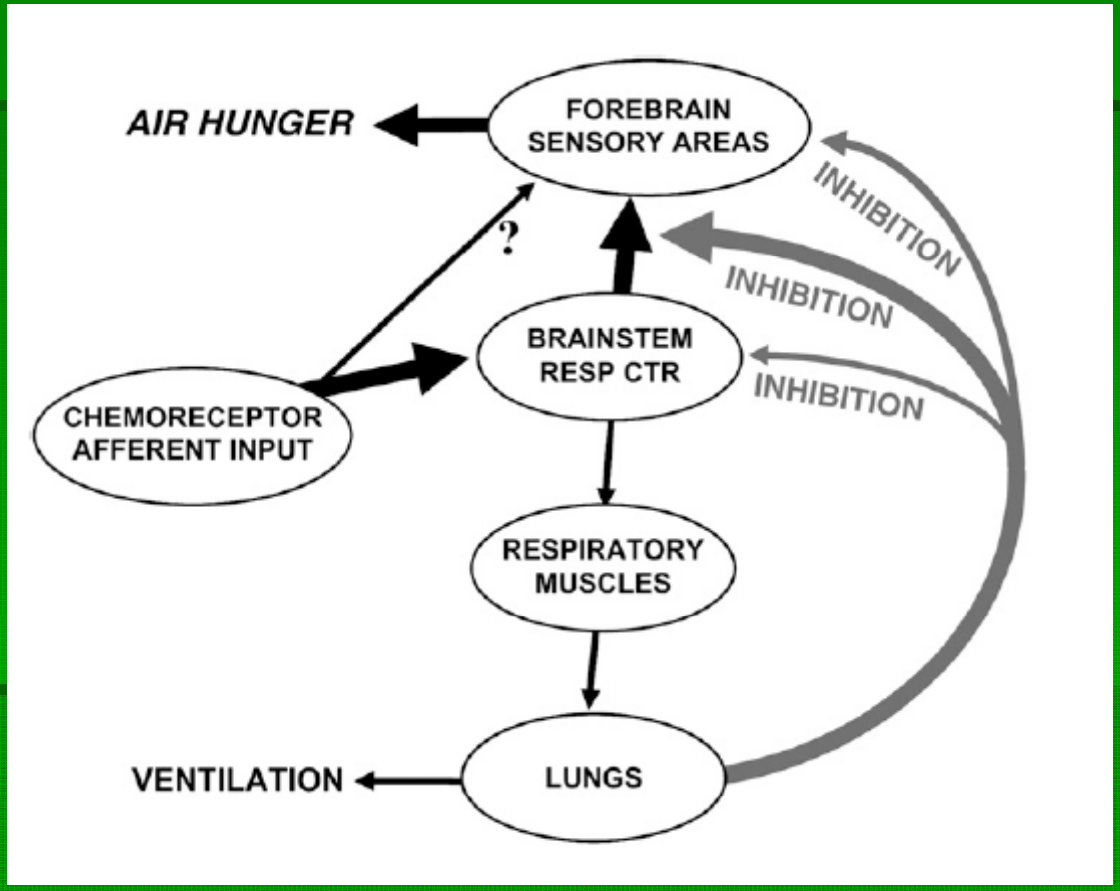
Dissociation between dyspnea & respiratory effort



Mean Change in Effort and Breathlessness Rating for Each Subject for Conditions A (PCO_2 = 40) and B (PCO_2 = 50)

Am Rev Respir Dis 1992; 146:1222-1225

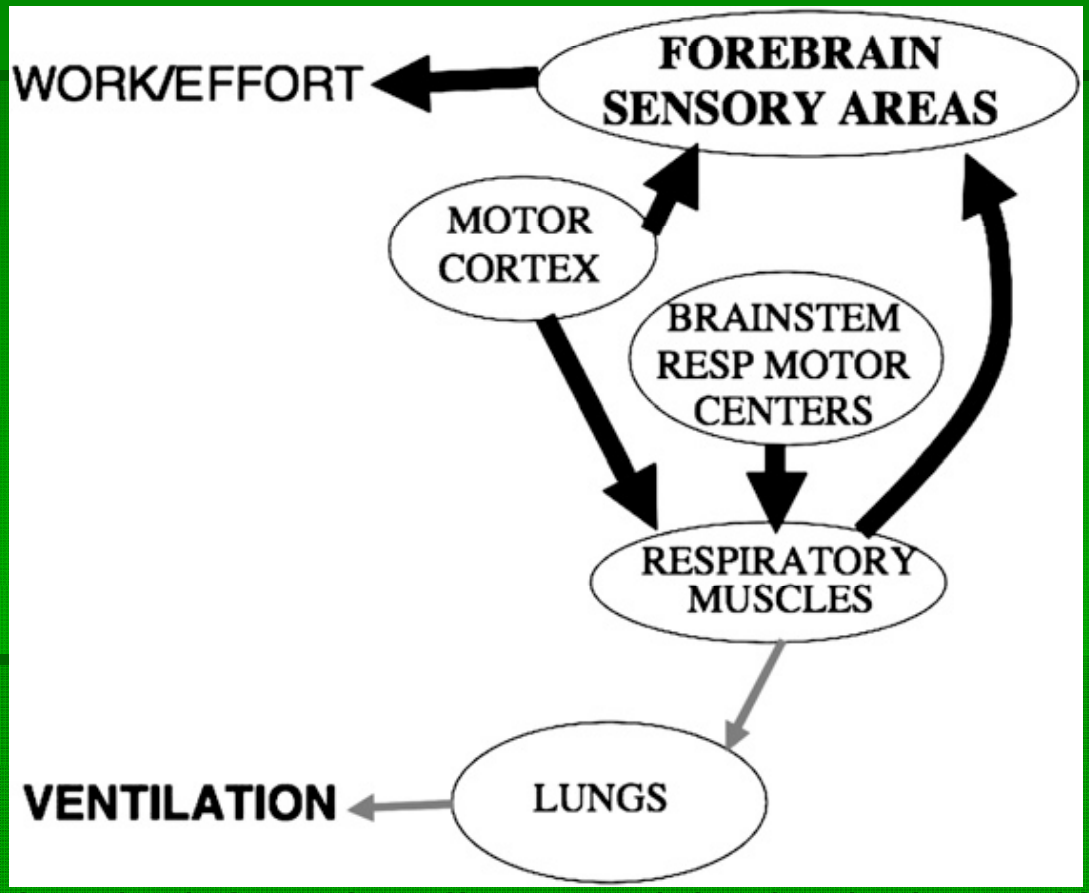
Mechanism of air hunger



Mismatch between automatic drive to breathe and achieved ventilation

Proc Am Thorac Soc Vol 4. pp 145–168, 2007

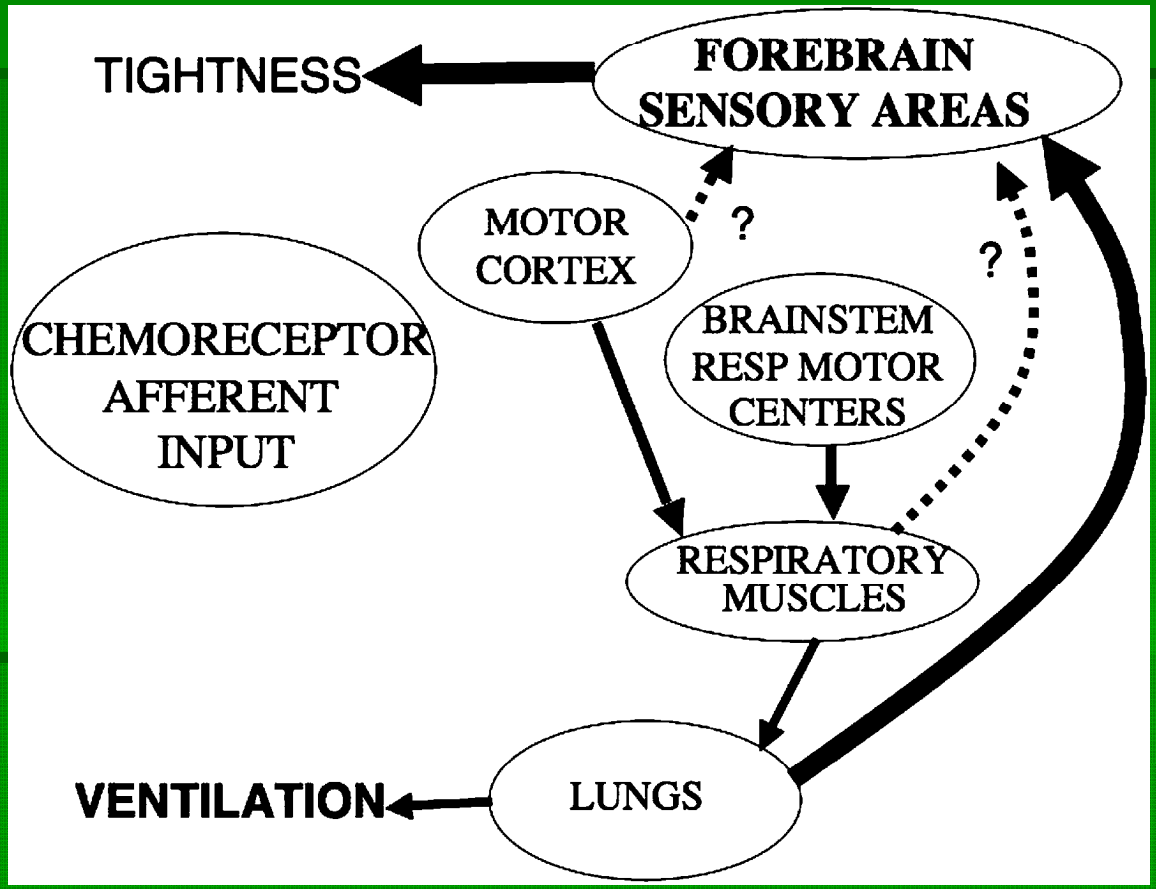
Mechanism of sense of effort



sensation arises both from the afferents originating in the working respiratory muscles and from the awareness of outgoing motor command from the motor cortex, as well as perhaps from the medulla (corollary discharge)

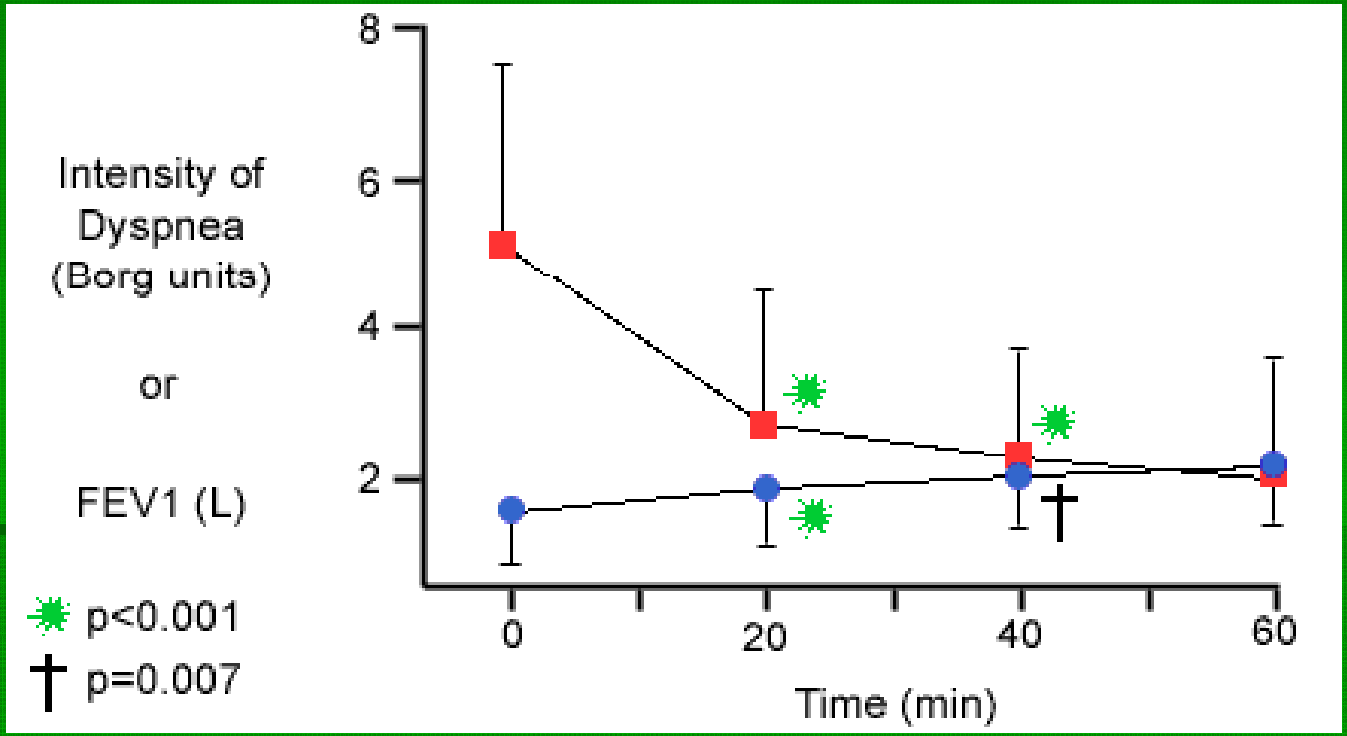
Proc Am Thorac Soc Vol 4. pp 145–168, 2007

Mechanism of chest tightness



Proc Am Thorac Soc Vol 4. pp 145–168, 2007

Intensity of Dyspnea as a Function of Time in Patients Presenting to an Emergency Department with Status Asthmaticus who are Treated with Albuterol at 20 Minute Intervals.



Am J Respir Crit Care Med. 2000;162:490-496

Dyspnea in Asthma

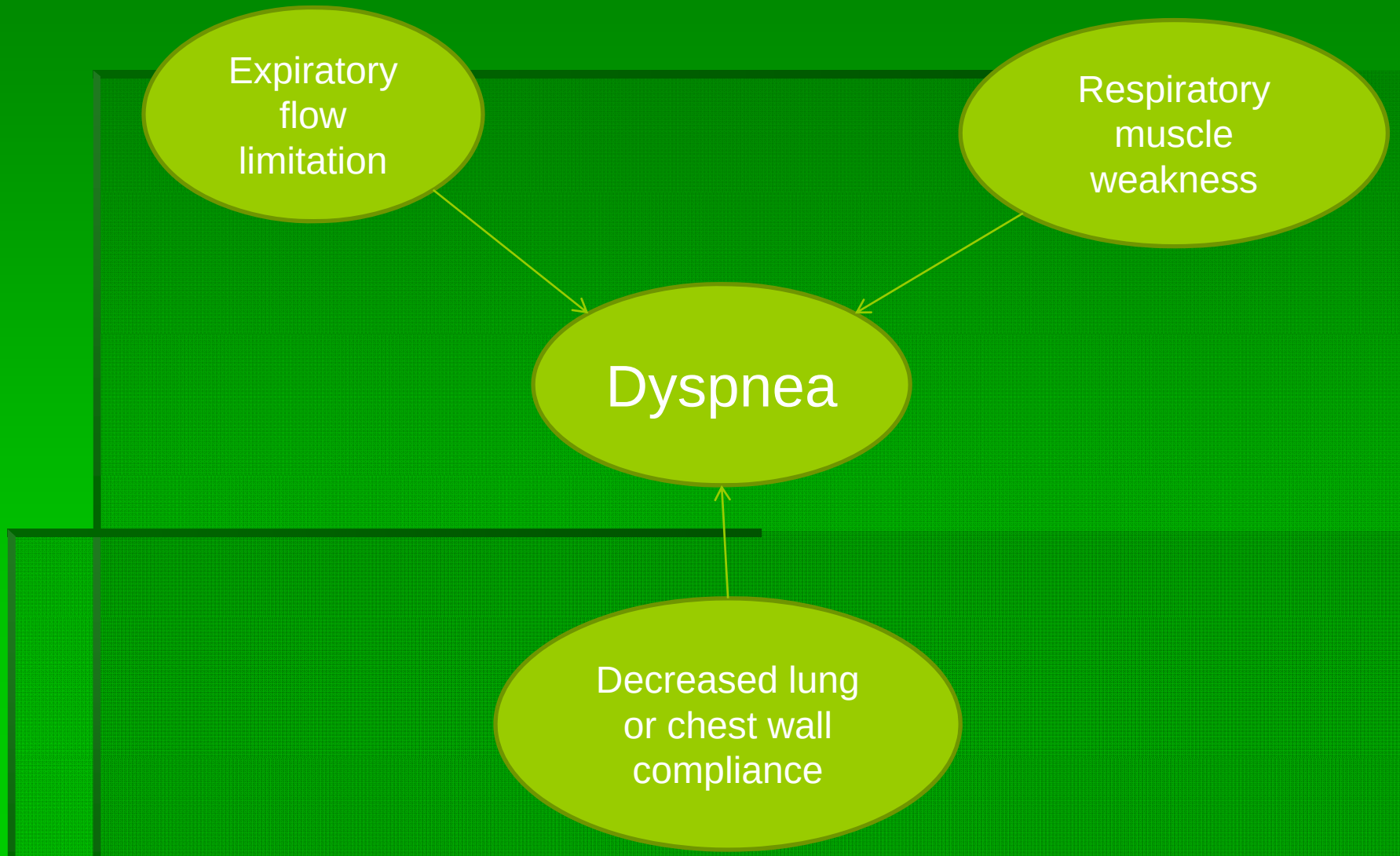
Methacholine induced bronchoconstriction	Dyspnea sensation	Mechanism
Mild	Chest tightness	Bronchoconstriction-induced stimulation of pulmonary receptors
Moderate	Sense of effort	Increased central motor command associated with the worsening mechanical load on the system
Severe	Air hunger	Even greater central motor activity

DYSPNEA
IN SOME COMMON DISORDERS

CONDITION	MECHANISM
Asthma	Increased sense of effort Stimulation of irritant receptors in airways
Neuromuscular disease	Increased sense of effort
COPD	Increased sense of effort Hypoxia Hypercapnia Dynamic airway compression
Mechanical ventilation	Afferent mismatch Factors associated with the underlying condition
Pulmonary embolism	Stimulation of pressure receptors in pulmonary vasculature or right atrium (?)

NEJM 1995

Clinical correlate of dyspnea



Respiratory Muscle weakness

- Weakness or mechanical inefficiency of the respiratory muscles results in a mismatch between central respiratory motor output and achieved ventilation.
- Fall in pressure-generating capacity of the respiratory muscles
- Increased ratio of the pressures produced by respiratory muscles to the maximum pressure that can be achieved → worsening dyspnea

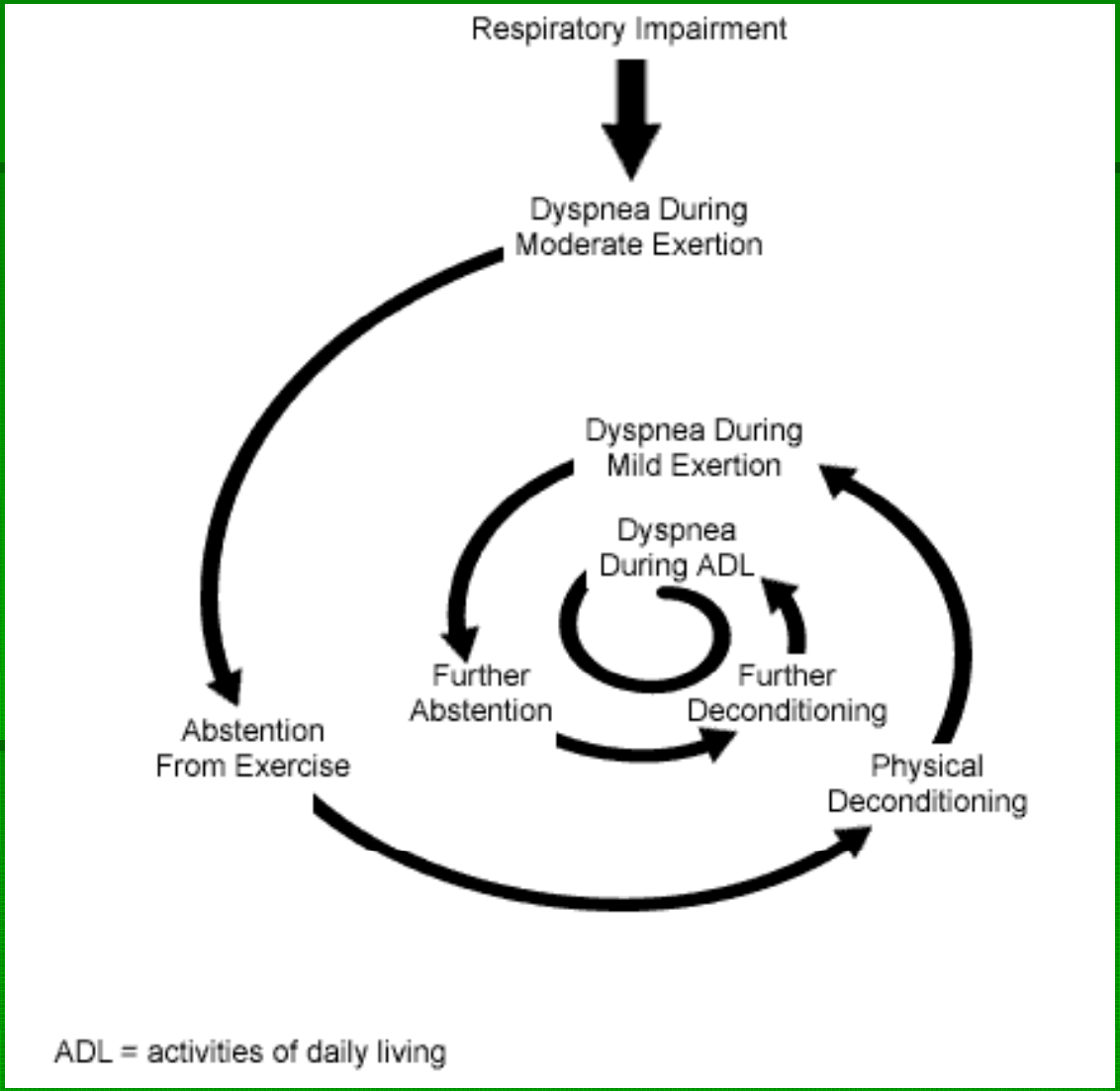
Poor respiratory system compliance

- Reduced lung compliance and decreased lung volumes
- Reduced vital capacity and functional residual capacity
- Unable to generate adequate tidal volumes in response to increased neural motor output is likely the basis for the dyspnea and rapid, shallow breathing

Psychologic Effects and Higher Brain Center Influences in dyspnea

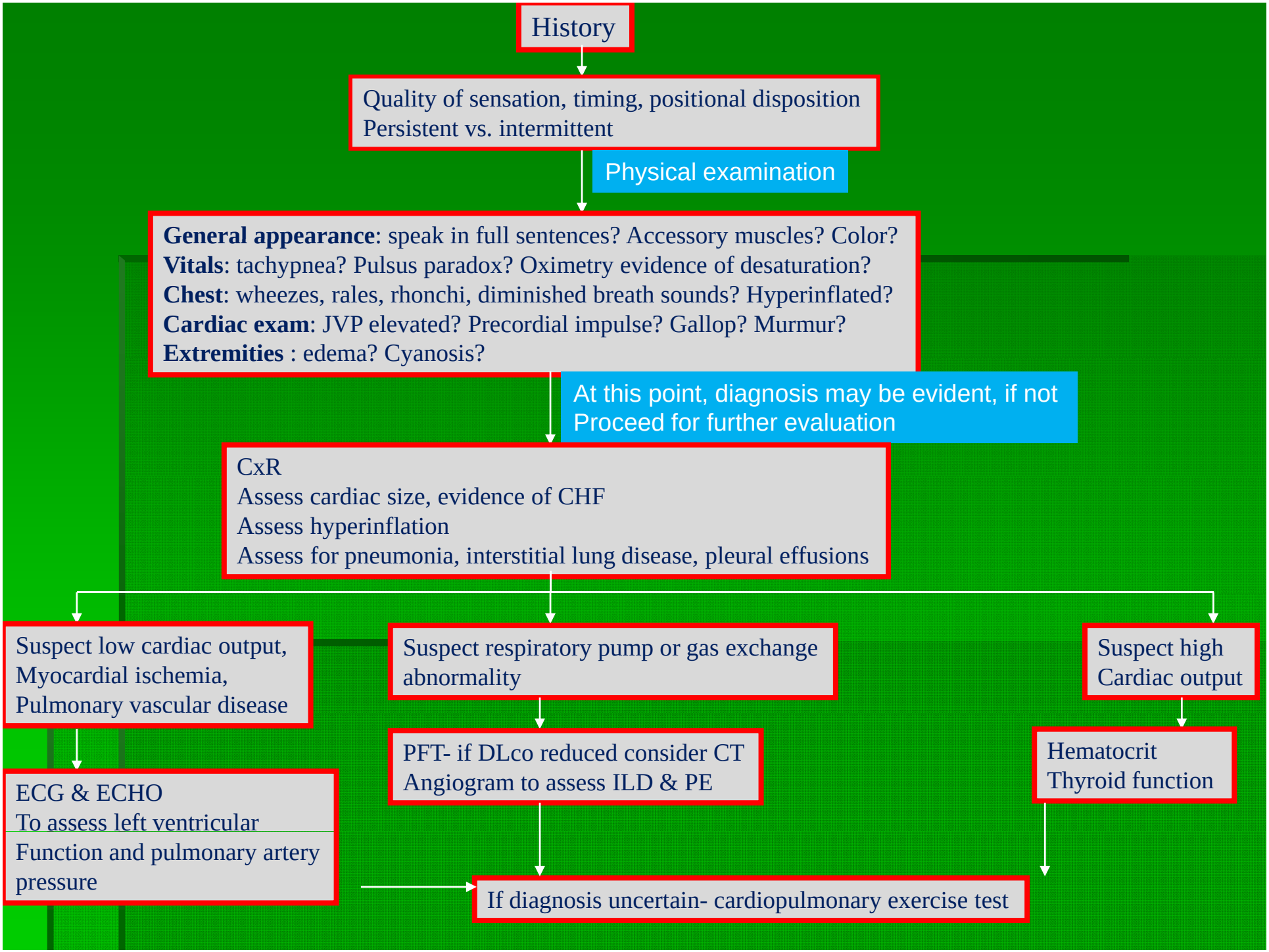
- Anxiety, anger, and depression can increase dyspnea out of proportion to the impairment in cardiorespiratory function
- Quality and intensity of dyspnea at a given level of respiratory activity are also thought to be shaped by patient experience, expectation, behavioral style, and emotional state
- Relationship between dyspnea and the degree of impairment in lung function is not strong

The Dyspnea Spiral



Principles and Practice of Pulmonary Rehabilitation

DYSPNEA ASSESSMENT


History
Quality of sensation, timing, positional disposition
Persistent vs. intermittent
Physical examination
General appearance: speak in full sentences? Accessory muscles? Color?
Vitals: tachypnea? Pulsus paradox? Oximetry evidence of desaturation?
Chest: wheezes, rales, rhonchi, diminished breath sounds? Hyperinflated?
Cardiac exam: JVP elevated? Precordial impulse? Gallop? Murmur?
Extremities : edema? Cyanosis?
At this point, diagnosis may be evident, if not
Proceed for further evaluation
CxR
Assess cardiac size, evidence of CHF
Assess hyperinflation
Assess for pneumonia, interstitial lung disease, pleural effusions
Suspect low cardiac output,
Myocardial ischemia,
Pulmonary vascular disease
Suspect respiratory pump or gas exchange abnormality
Suspect high
Cardiac output
ECG & ECHO
To assess left ventricular
Function and pulmonary artery pressure
PFT- if DLco reduced consider CT
Angiogram to assess ILD & PE
Hematocrit
Thyroid function
If diagnosis uncertain- cardiopulmonary exercise test

Dysnea scale: Indirect measurement

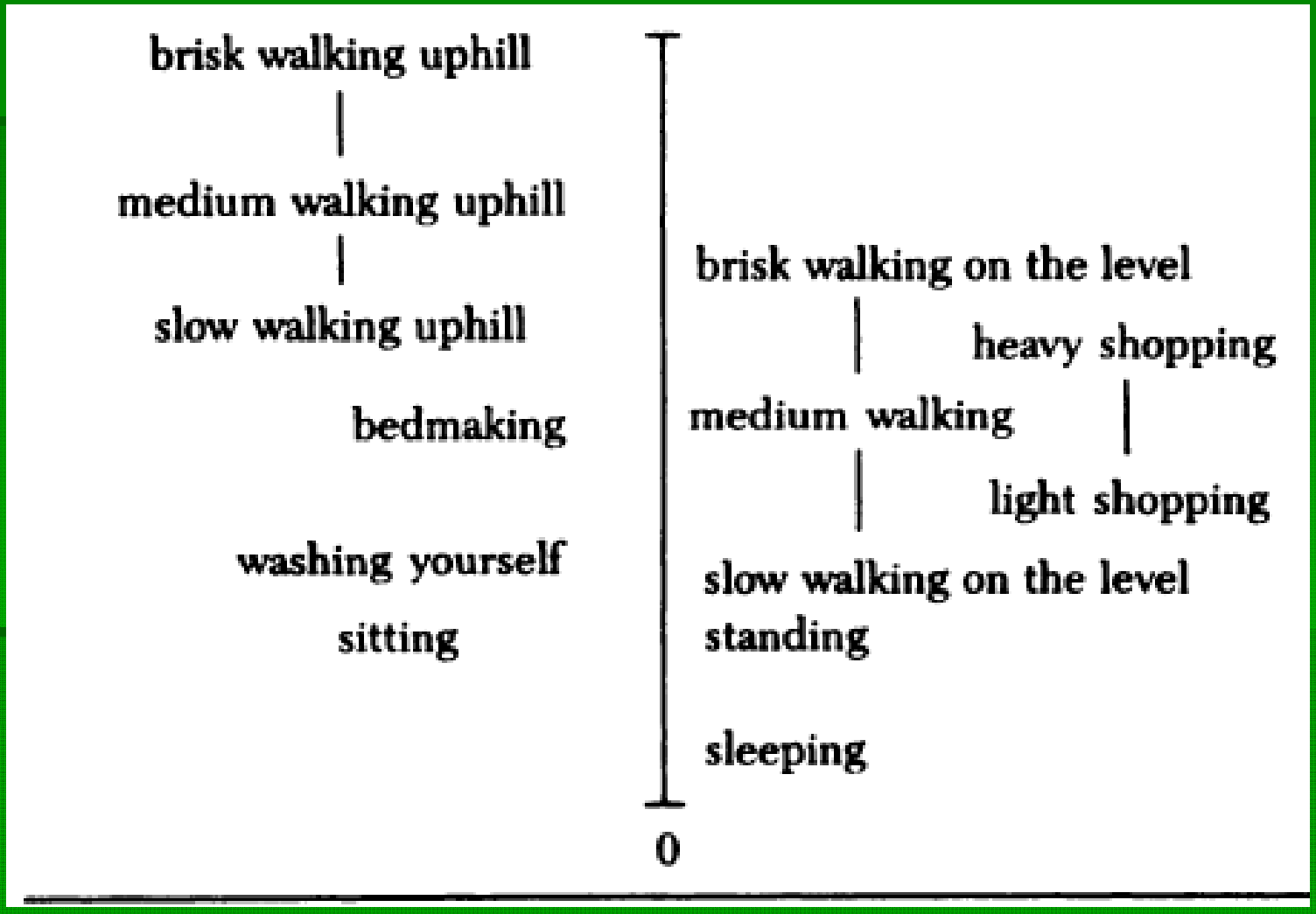
Scale	Advantages	Disadvantages
Medical Research Council (MRC) Oxygen Cost Demand (OCD)	Easy	Difficult following after intervention Consider single dimension – magnitude of task
Baseline Dyspnea Index (BDI) Transition Dyspnea Index (TDI)	includes measurement of functional impairment (the degree to which activities of daily living are impaired) and magnitude of effort (the overall effort exerted to perform activities) and	
	magnitude of task	

Modified Medical Research Council Dyspnea Scale (MMRC Scale)

Grade	Description
0	Not troubled with breathlessness except with strenuous exercise
1	Troubled by shortness of breath when hurrying on the level or walking up a slight hill
2	Walks slower than people of the same age on the level because of breathlessness or has to stop for breath when walking at own pace on the level
3	Stops for breath after walking about 100 yards or after a few minutes on the level
4	Too breathless to leave the house or breathless when dressing or undressing

ATS News 1982; 8:12-16

Oxygen Cost Diagram



Br Med J 1978; 2:241-43.

University of California at San Diego Shortness of Breath Questionnaire (UCSDQ)

- 24-item questionnaire measuring dyspnea during the past week
- Asked about the frequency of dyspnea when performing 21 different activities on a six-point rating scale
- Three additional questions inquire about activity limitations due to shortness of breath, fear of harm from overexertion, and fear of shortness of breath.
- Reliability and validity for the instrument have been reported

Dyspnea scale: Direct measurement

- Cycle ergometry
- 6-min walk test
- Methacholine challenge test

Visual Analogue Scale (VAS)

- 100 mm in length, placed either horizontally or vertically

Dyspnea and Quality of Life: Broadening Conceptions

- Quality-of-life measures are designed to measure how patients function physically, emotionally, socially, and occupationally in their day-to-day lives as a result of their cardiopulmonary disease.
- Improvements in these measures have been shown in some patients to be independent of changes in severity of disease.
- Questionnaires of this type usually appraise dyspnea within the context of a disease that interferes with the individual's life.

Chronic Respiratory Disease Questionnaire (CRQ)

- 20-item questionnaire evaluating four dimensions of illness: dyspnea, fatigue, emotional function, and mastery
- Each patient is asked to select the five most bothersome activities that elicited breathlessness during the last 2 wk.
- After the patient determines the five most important activities affecting daily life, the severity of breathlessness is determined on a seven-point scale.
- The activities identified are, naturally, unique to the patient and make comparisons of dyspnea scores with other patients difficult.
- Reliability and validity estimates for the CRQ have been reported

Saint George Respiratory Questionnaire (SGRQ)

- self-administered 76-item questionnaire measuring three areas: symptoms, activity, and impact of disease on daily life.
- Administration time is 20 min.
- Dyspnea is not evaluated specifically but rather included in the symptom category along with information about cough, sputum, and wheezing.
- The SGRQ has been translated into several languages, and reliability and validity estimates have been reported

Pulmonary Functional Status and Dyspnea Questionnaire (PFSDQ)

- Impact of respiratory distress on functional performance of day-to-day activities
- The patient assesses his/her ability to perform various activities as well as the amount of associated dyspnea.
- Dyspnea is also evaluated with three general appraisal questions that create global dyspnea scores that are separate from the score for dyspnea with activity.
- Reliability and validity estimates of the PFSDQ have been reported

Pulmonary Functional Status Scale (PFSS)

- Self administered questionnaire measuring the mental, physical, and social functioning of the patient with COPD
- Dyspnea ratings are obtained in relation to several activities and reflected in a dyspnea subscale.
- Reliability and validity estimates for both scales have been reported

TREATMENT OF DYSPNEA

- Effectively alleviated by treatment of the underlying disease and its complications
- Focus should be on alleviating symptoms as well as improving pulmonary function
- When dyspnea persists despite optimal treatment of the underlying disease, treatment should focus on the symptom rather than the disease and particularly on the specific mechanisms contributing to an individual's dyspnea

Lung volume reduction surgery for relief of dyspnea in advanced emphysema

- Removal of multiple bullous or emphysematous portions of the lungs reduces hyperinflation and improves lung recoil, potentially leading to dramatic improvement in pulmonary function and dyspnea.

- National Emphysema Therapy Trial (NETT) showed that in patients with heterogeneous emphysema with upper lobe predominance and low exercise tolerance the operation not only relieves dyspnea but prolongs life.

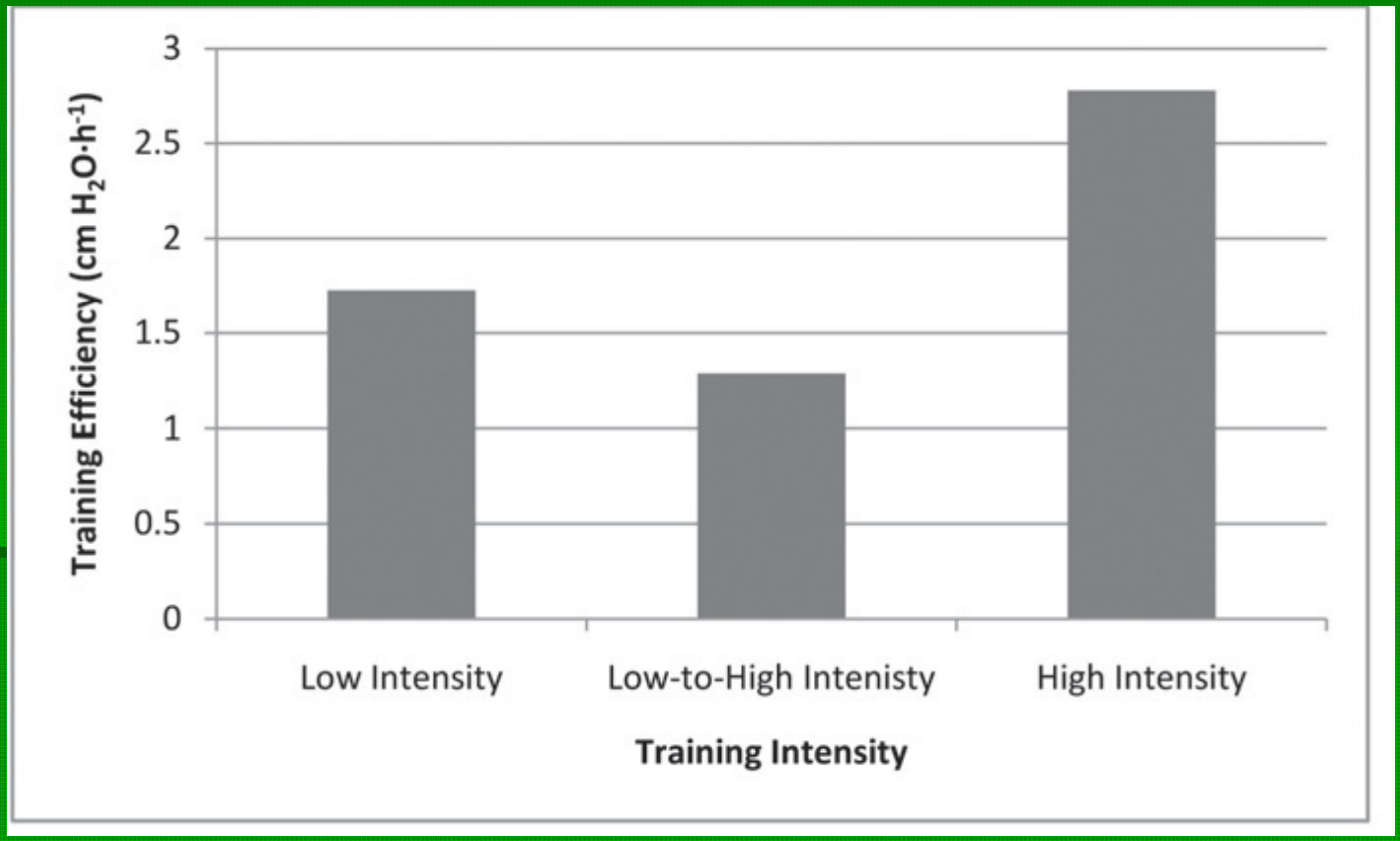
Thorax 1999; 54:779-789

Eur Respir J 2002; 19:54-60

REDUCING RESPIRATORY EFFORT AND IMPROVING RESPIRATORY MUSCLE FUNCTION

- Energy conservation techniques reduce physical effort (e.g., walking more slowly) so less ventilatory effort is necessary.
- Breathing techniques (e.g., pursed lips) may reduce respiratory discomfort by slowing breathing and improving oxygen saturation
- If ventilation limits exercise, strengthening the respiratory muscles should improve maximal ventilation and exercise performance, thereby alleviating the dyspnea.
- Unfortunately the results of this approach have been inconsistent

Inspiratory Muscle Training in Patients with Chronic Obstructive Pulmonary Disease: The State of the Evidence



Cardiopulmonary Physical Therapy Journal 2009;23:5-15

Supplemental Oxygen - ↓Respiratory Drive

- Supplemental oxygen can reduce carotid body activation, resulting in prolonged breath-holding time
- Decrease dyspnea by decreasing ventilation with exercise
- Direct central effect on dyspnea apart from its effect on ventilation, improved ventilatory muscle function, left ventricular contractility, and pulmonary artery pressure
- The amount of oxygen should be titrated to prevent desaturation below 90%, although even higher amounts may be advantageous for preventing dyspnea and improving exercise performance.

Pulmonary Rehabilitation

- Best studied formally in obstructive lung disease (but theoretically of use in other conditions), the key concepts are modifying behavior both to avoid a vicious cycle of deconditioning and to encourage energy-saving

Oxford University Press, 2006; 137-155

ALTERING CENTRAL PERCEPTION

- Experience of dyspnea is affected by many factors, including education, cultural background, knowledge, emotional state, bodily preoccupation, and prior experience
- Cognitive behavioural therapy → role

Drugs

Opioids	**Respiratory depression** **Decreased sensitivity to chemoreceptors** **Effrent reafferent dissociation**
Benzodiazepines	Palliative care
Theophylline	Improve diaphram function