

# Medical Emergencies at Moderate and High Altitude

Payer Hutte, Ortler

**Annalisa Cogo**

**Clinica Pneumologica e Centro Studi Biomedici Applicati allo Sport  
Università di Ferrara**



# Mountain Environment



**Barometric Pressure**



**PiO<sub>2</sub>**



**Air Density**



**Temperature**



**Humidity**



**Wind**



**Allergens**



**Pollution**



**Solar radiation**



# Altitude Classification

## 0-500 m Near Sea Level

No altitude-related effects on well-being or athletic performance

## 500-2000m Low Altitude

No altitude-related effects on well-being but relevant impairment of performance possible, particularly in highly trained athletes > 1500 m. This can be overcome completely by acclimatization.

## 2000-3000m Moderate Altitude

**Effects of altitude on well-being in non-acclimatized subjects with minor sleep disturbances or symptoms of AMS may occur after  $\geq 9$  hours of exposure. Discomfort is transient during the first days.  $VO_2\max$   $\downarrow$  significantly but can be restored largely by acclimatization.**

**Significant erythropoietic response occurs within 3–4 weeks.**

### 3000-5500 High Altitude

AMS occurs in a large number of non-acclimatized individuals during the first days of exposure. Susceptible individuals may develop HAPE > 3000 m a.s.l. and HACE > 4000 m a.s.l. Staged ascent is recommended to avoid these illnesses. The altitude will significantly reduce VO<sub>2</sub>max even after full acclimatization.

### > 5500m Extreme Altitude

5500 m a.s.l. appears to be the ceiling for long-term adaptation in humans, as the highest permanent settlements are at this altitude

Accidents and deaths in the mountains are most commonly due to trauma, high altitude illness, cold injury, avalanche burial, and sudden cardiac death.



**Emergencies due to:**

**Altitude illness**

**Respiratory Diseases**



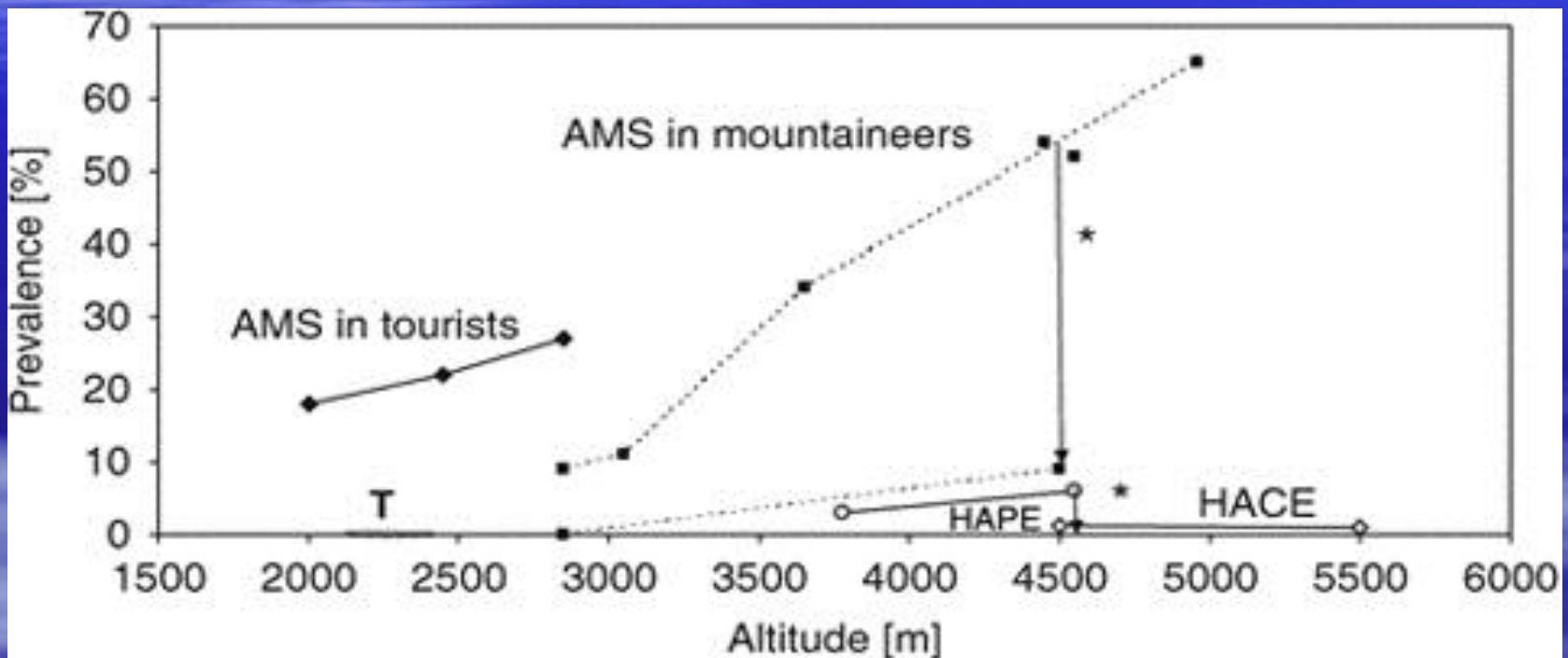
# Risk Categories for Acute Mountain Sickness

**Table 3.** Risk categories for acute mountain sickness

<i>Risk category</i>	<i>Description</i>
Low	<ul style="list-style-type: none"><li>● Individuals with no prior history of altitude illness and ascending to <math>\leq 2800</math> m;</li><li>● Individuals taking <math>\geq 2</math> days to arrive at 2500-3000 m with subsequent increases in sleeping elevation <math>&lt; 500</math> m/d</li></ul>
Moderate	<ul style="list-style-type: none"><li>● Individuals with prior history of AMS and ascending to 2500-2800 m in 1 day</li><li>● No history of AMS and ascending to <math>&gt; 2800</math> m in 1 day</li><li>● All individuals ascending <math>&gt; 500</math> m/d (increase in sleeping elevation) at altitudes above 3000 m</li></ul>
High	<ul style="list-style-type: none"><li>● History of AMS and ascending to <math>\geq 2800</math> m in 1 day</li><li>● All individuals with a prior history of HAPE or HACE</li><li>● All individuals ascending to <math>&gt; 3500</math> m in 1 day</li><li>● All individuals ascending <math>&gt; 500</math> m/d increase in sleeping elevation) above <math>&gt; 3500</math> m</li><li>● Very rapid ascents (eg, Mt. Kilimanjaro)</li></ul>

# Acute Mountain Sickness

Maladaptive Response to High Altitude exposure  
Too High Too Fast



Prevalence of acute high-altitude illnesses at various altitudes. *T* indicates the threshold altitude range for symptoms induced by hypoxia at rest (Muhm et al 2007) and asterisk indicates effects of acclimatization and slow ascent.

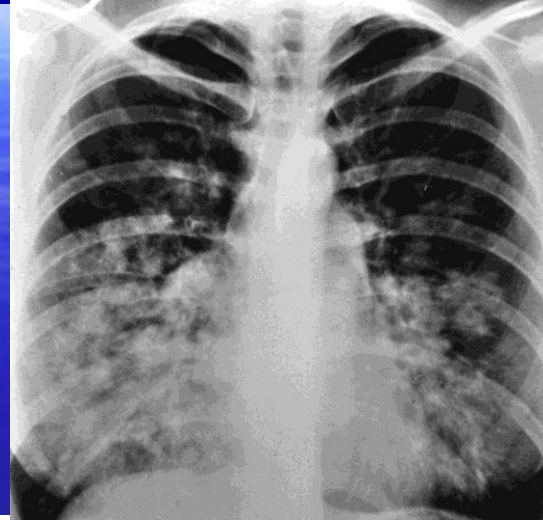
Bartsch P, Scand J Med Sci Sports 2008

# Symptoms of AMS-HACE

**Table 4.** Acute mountain sickness classification

<i>Category</i>	<i>Mild AMS</i>	<i>Moderate–Severe AMS</i>	<i>HACE</i>
Symptoms	Headache plus 1 or more other symptom (nausea/vomiting; fatigue, lassitude, dizziness; difficulty sleeping). All symptoms of mild intensity	Headache plus 1 or more other symptom (nausea/vomiting; fatigue, lassitude, dizziness; difficulty sleeping). All symptoms of moderate–severe intensity	Worsening of symptoms seen in moderate to severe AMS
Signs	None	None	Ataxia, severe lassitude, altered mental status, encephalopathy
Lake Louise AMS Score <sup>a</sup>	2–4	5–15	Not applicable

# High altitude Pulmonary Edema (HAPE)



**HAPE is a non-cardiogenic edema that is due to a non-inflammatory capillary leak caused by an abnormally high hypoxic pulmonary vasoconstriction and increased endothelial permeability**

**HAPE is rare < 3000 m a.s.l. Prevalence of HAPE after rapid ascent to 4550 m a.s.l. within 24 h, is 6% in a general mountaineering population and 60–70% in HAPE-susceptible individuals, characterized by an abnormal increase in pulmonary artery pressure with exposure to hypoxia**

# Descent when feasible, descent remains the single best treatment for altitude illness

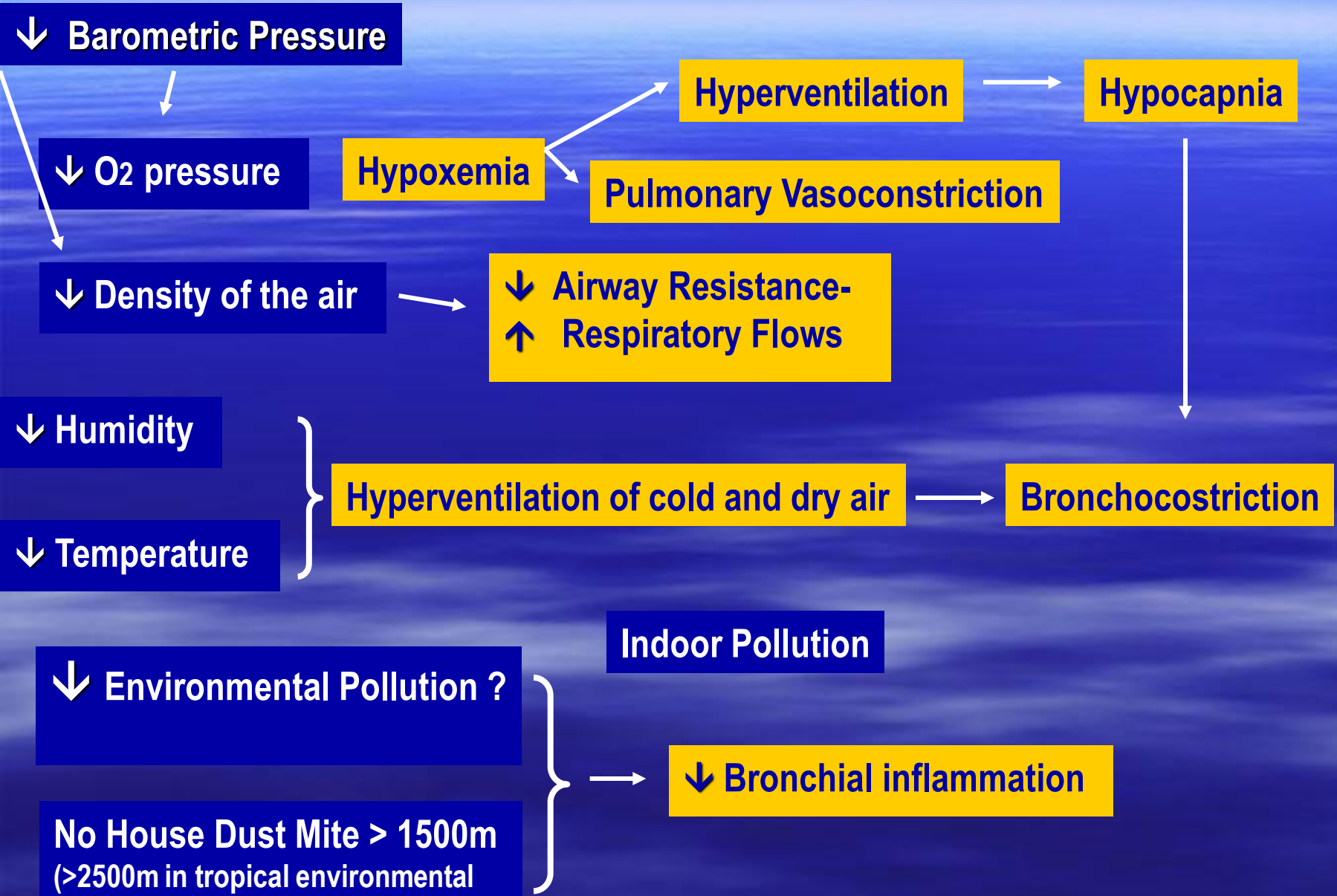
Supplemental O<sub>2</sub> → SpO<sub>2</sub> >90%

Portable hyperbaric chambers

**Table 2.** Recommended dosages for medications used in the prevention and treatment of altitude illness

<i>Medication</i>	<i>Indication</i>	<i>Route</i>	<i>Dosage</i>
Acetazolamide	AMS, HACE prevention	Oral	125 mg twice per day Pediatrics: 2.5 mg/kg every 12 h
	AMS treatment <sup>a</sup>	Oral	250 mg twice per day Pediatrics: 2.5 mg/kg every 12 h
Dexamethasone	AMS, HACE prevention	Oral	2 mg every 6 h or 4 mg every 12 h Pediatrics: should not be used for prophylaxis
	AMS, HACE treatment	Oral, IV, IM	AMS: 4 mg every 6 h HACE: 8 mg once then 4 mg every 6 h Pediatrics: 0.15 mg/kg/dose every 6 h
Nifedipine	HAPE prevention	Oral	30 mg SR version, every 12 hours or 20 mg of SR version every 8 h
	HAPE treatment	Oral	30 mg SR version, every 12 hours or 20 mg of SR version every 8 h
Tadalafil	HAPE prevention	Oral	10 mg twice per day
Sildenafil	HAPE prevention	Oral	50 mg every 8 h
Salmeterol	HAPE prevention	Inhaled	125 μg twice per day <sup>b</sup>

# The Lung and the Mountain Climate



# Exercise Induced Bronchospasm

A variable percentage (60% to 80%) of asthmatics suffer from **exercise-induced bronchoconstriction (EIB)**, = acute transient airway narrowing occurring during /after a prolonged, submaximal exercise.

**Stimulus for EIB:** the evaporative water loss from the airway →  $\Delta$ osmolarity of the airways periciliary fluid  
→ release of mediators,.

At altitude, hyperventilation of cold air, especially during exercise, has a considerable potential for airways dehydration → risk of an asthma attack.

# Asthma in the Mountain: recommendations 1

**General rule: asthma must be under control and in a stable state =  
NO frequent use (>3 times weekly) of inhaled bronchodilators before travel**

**Asthmatics who frequently use inhaled bronchodilators before travel are at increased risk to develop asthma attacks and should be discouraged from participating in high altitude treks.**

**Therapy should be adjusted to achieve better disease control before leaving.**

**During Upper Airway Infection, asthmatics are at increased risk of exacerbations**



## Asthma Management and Prevention Program Component 4: Manage Asthma Exacerbations

Exacerbations of asthma are episodes of progressive increase in shortness of breath, cough, wheezing, or chest tightness

Exacerbations are characterized by decreases in expiratory airflow that can be quantified and monitored by measurement of lung function ( $FEV_1$  or PEF)

Severe exacerbations are potentially life-threatening and treatment requires close supervision

# Severity of Asthma Exacerbations

## Life threatening

PEF < 33%

SpO<sub>2</sub> < 92%

Examination: no breath

Cyanosis

Bradycardia/Arrhythmia

Hypotension

Obnubilation

Lassitude

## Severe

PEF 33 - 50%

RR ≥ 25

HR ≥ 110

Unable to speak more than few words

## Mild-Moderate

Symptoms Worsening

PEF 50 - 75%

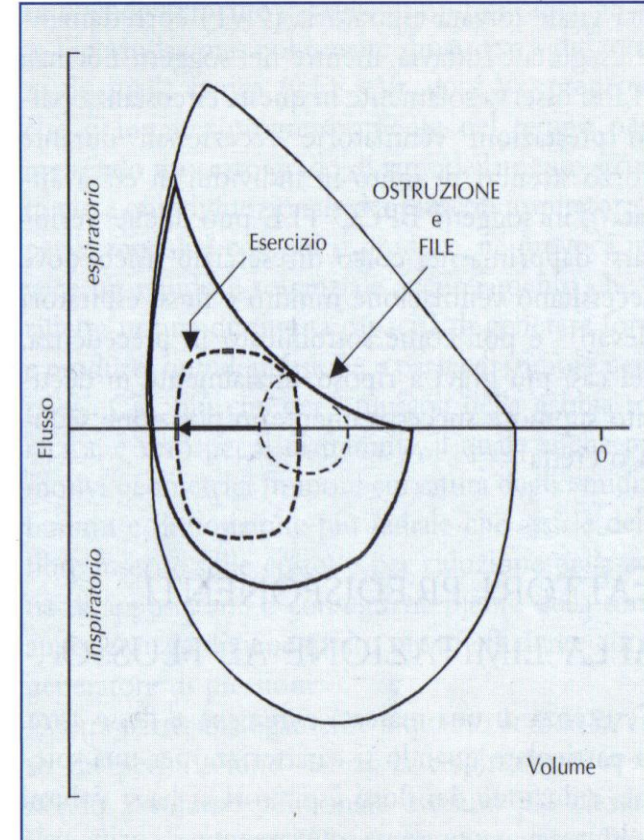
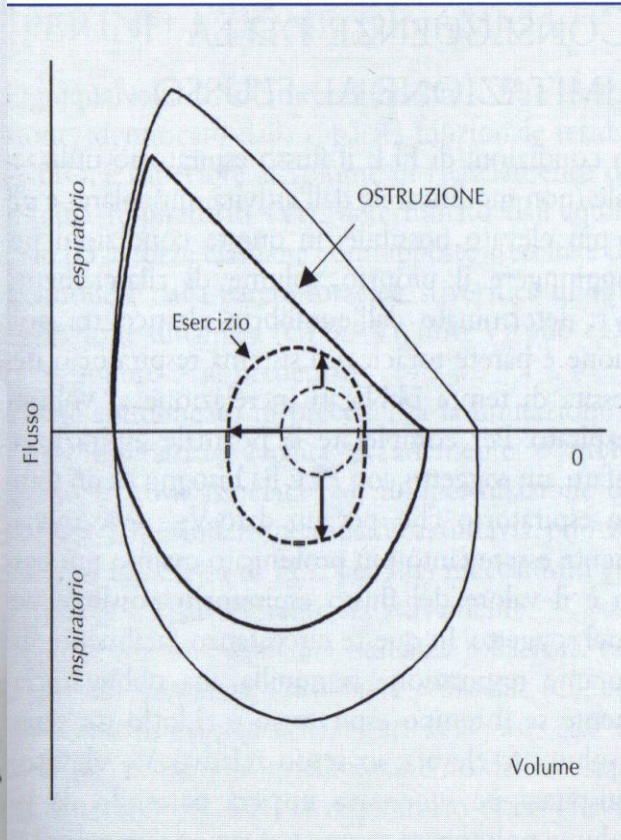
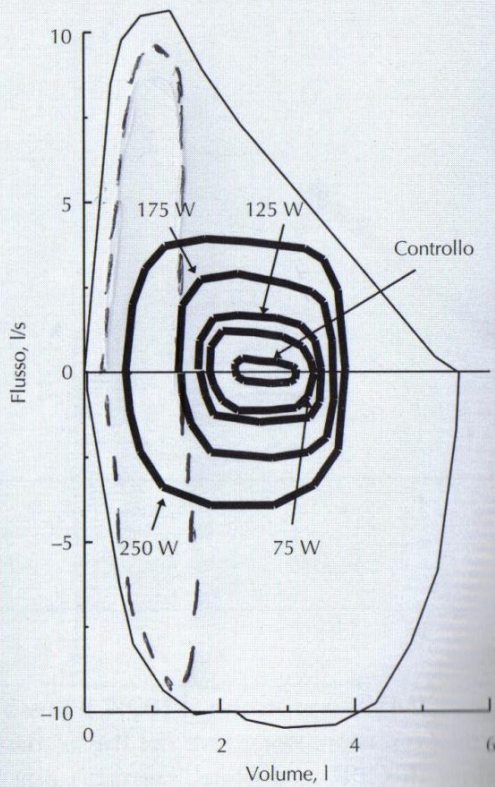
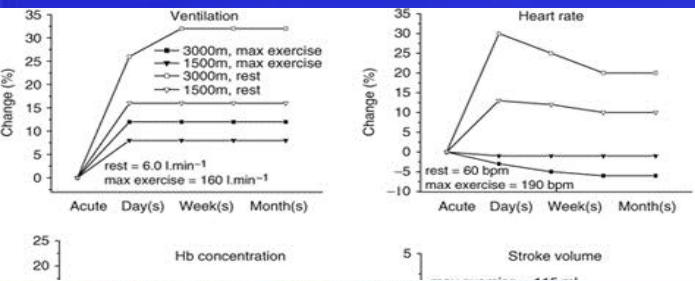


## Asthma Management and Prevention Program Component 4: Manage Asthma Exacerbations

### Primary therapies for exacerbations:

- ✓ **Repetitive administration of rapid-acting inhaled  $\beta_2$ -agonist**  
albuterol 100 mcg, 2-4 puff every 3-4 hours or nebulised albuterol+ anticholinergic
- ✓ **Early introduction of systemic glucocorticosteroids**  
Prednisone 25-50mg immediately  
Inhaled corticosteroid are very effective (up to 4mg budesonide)
- ✓ **Oxygen supplementation**
- ✓ **Closely monitor response to treatment with serial measures of lung function (PEF)**

# Increased Ventilatory demands



Ventilation during incremental exercise test in healthy subjects

Ventilation during incremental exercise test in COPD subjects

# Key Question: the level of PaO<sub>2</sub> at altitude

Is the COPD patient able to maintain an adequate PaO<sub>2</sub>?

altitude	SI PaO <sub>2</sub>	Alt PaO <sub>2</sub>	References
1900m	66	54	Graham 1978
1524	68	55	Gong 1984*
2348	72	55	Gong 1984*
3048	72	50	Christensen 2000

\* In the mountain

# Manage COPD Worsening at Altitude

## Primary therapies for exacerbations:

✓ **Descent**

✓ **Oxygen supplementation**

✓ **Repetitive administration of rapid-acting inhaled  $\beta_2$ -agonist**  
albuterol 100 mcg, 2-4 puff every 3-4 hours or nebulised albuterol+ anticholinergic

✓ **Early introduction of systemic glucocorticosteroids**

Prednisone 25-50mg immediately



THANKS

