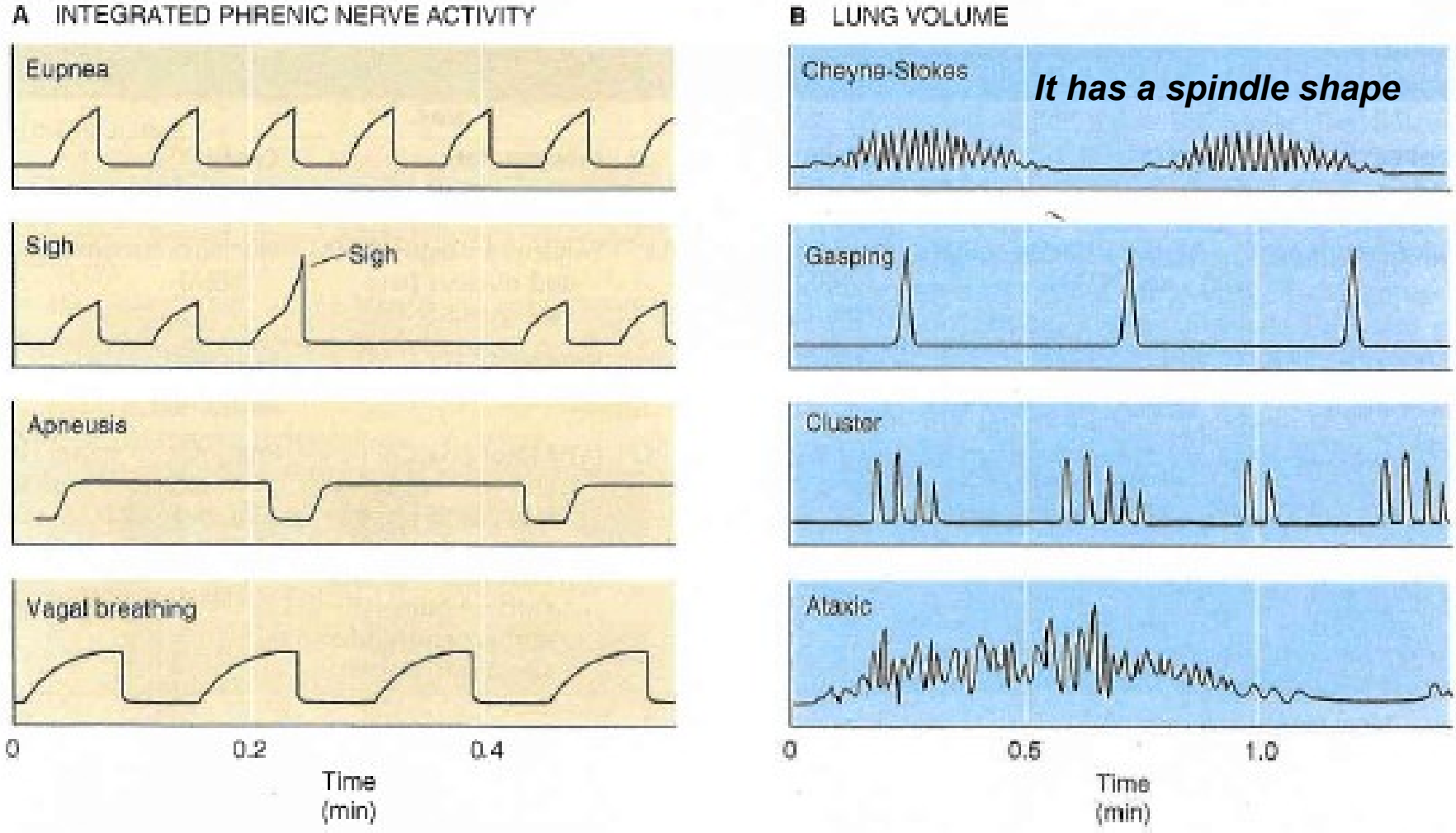
HYPOXIA

Periodic breathing

- It is not regular, rhythmic, but respiration occurs in periods ("a moment to breathe, take a moment to not breathe„)

- **CHEYNE-STOKES**
- **BIOT‘S**
- „gasping“
- KUSSMAUL


A INTEGRATED PHRENIC NERVE ACTIVITY
Eupnea
Sigh
Sigh
Apneusis
Vagal breathing
0
0.2
0.4
Time
(min)
B LUNG VOLUME
Cheyne-Stokes
It has a spindle shape
Gasping
Cluster
Ataxic
0
0.5
1.0
Time
(min)

Hypoxia, hypoxemia

- **Hypoxia** is a general name for a lack of oxygen in the body or individual tissues.
- **Hypoxemia** is lack of oxygen in arterial blood.
- Complete lack of oxygen is known as **anoxia.**

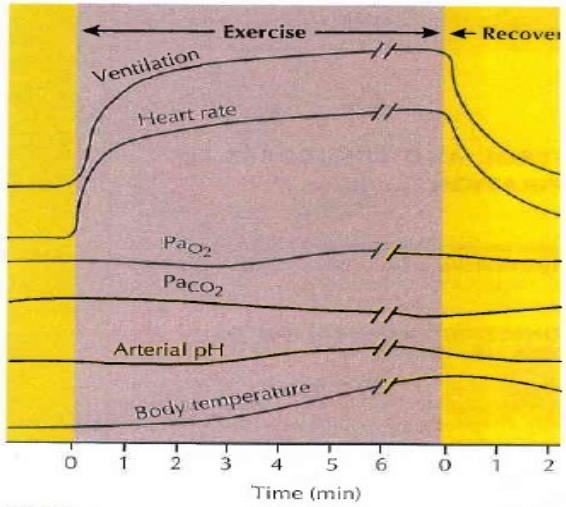
The most common types of hypoxia:

1. Hypoxic - physiological: stay at higher altitudes, pathological: hypoventilation during lung or neuromuscular diseases
2. Transport (anemic) - reduced transport capacity of blood for oxygen (anemia, blood loss, CO poisoning)
3. Ischemic (stagnation) - restricted blood flow to tissue (heart failure, shock states, obstruction of an artery)
4. Histotoxic - cells are unable to utilize oxygen (cyanide poisoning - damage to the respiratory chain)

Hypercapnia

- Hypercapnia - increase of concentration of carbon dioxide in the blood or in tissues that is caused by retention of CO_2 in the body
- possible causes: total alveolar hypoventilation (decreased respiration or extension of dead space)
- mild hypercapnia (5 -7 kPa) causes stimulation of the respiratory center (therapeutic use: pneumoxid = mixture of oxygen + 2-5% CO_2)
- hypercapnia around 10 kPa - CO_2 narcosis - respiratory depression (preceded by headache, confusion, disorientation, a feeling of breathlessness)
- hypercapnia over 12 kPa - significant respiratory depression - coma and death.

Respiratory Response to Exercise

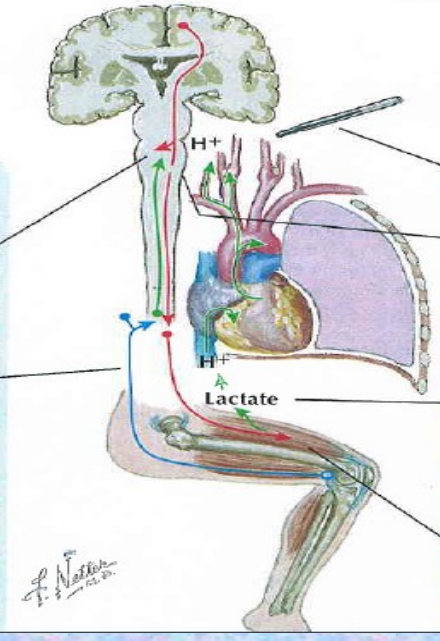


Factors that may account for initial abrupt rise and sharp terminal drop in ventilation

Collaterals to respiratory centers from motor pathways for muscle activation

Proprioceptive afferents from joint receptors to respiratory centers

Other unknown factors



Factors that may play a part in continued elevation of ventilation during continuing exerc

Rise in body temperatu accounts for a small pa of elevation

Respiratory neurons see to be more responsive t changes in chemorecep activity. Centers may b more sensitive to fluctuation than to absc values of Pa_{O_2}, Pa_{CO_2}, or pH

Lactic acid production due to anaerobic metabolism in muscle may increase H^+ concentration of blood and CSF, thus affecting chemoreceptors

Possible metaboreceptc in exercising muscle

Other unknown factors

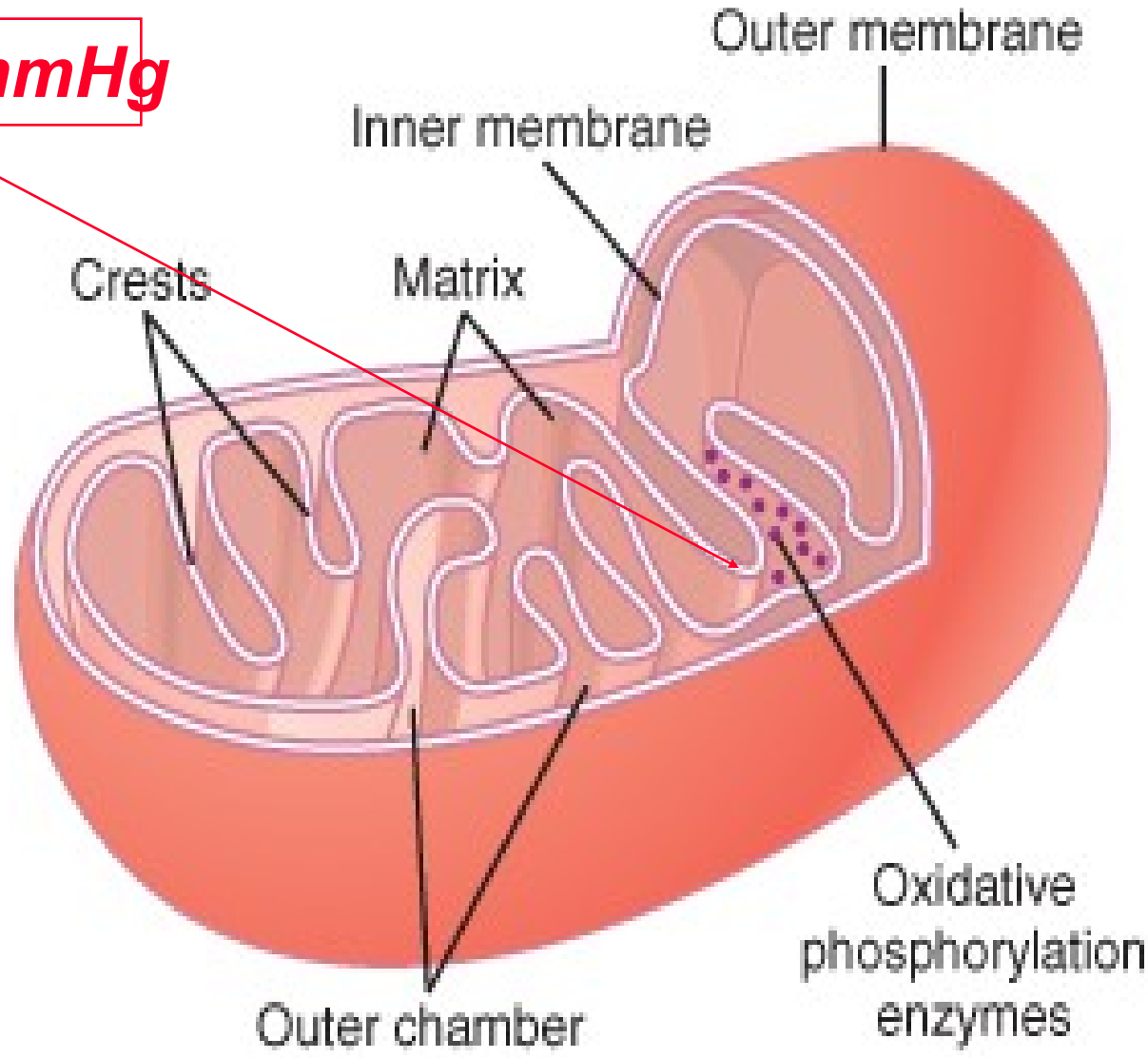
HYPOXIA

is oxygen deficiency at the cells or the tissue or the organs or the organism level

OXYGEN FALL

	mmHg
dry atmospheric air	*159*
humid atmospheric air	*149*
ideal alveolar gass	*105*
end-expirated air	*105*
Arterial blood	*77*
Cytoplasma – mitochondria	*3-10*
Mixed venous blood	*40*
Venous blood	*20*

$pO_2 = 1\ mmHg$



Hypoxia has been divided into following types:

1. ***Decrease oxidation of blood in the lung***
2. ***Pulmonary disease***
3. ***Venous-arterial shorts in circulation***
4. ***Oxygen transport disorder (blood – tissue)***
5. ***Decrease utilization of oxygen by the tissue***

1. Decrease oxidation of blood in the lung

- *hypoxic hypoxia:*
  - *lower oxygen in atmospherical air*
  - *hypoventilation (neuromuscular diseases)*

2. Pulmonary disease

-hypoventilation : increase airway resistance (asthma bronchiale) or pulmonary compliance

-

3. Venous – arterial shunts

from fetal circulation: ductus arteriosus Botali
foramen ovale

4. Oxygen transport disorder
(anemic hypoxia, stagnant hypoxia, ischemic hypoxia)

-Anemia
-Special type of hemoglobin (hemoglobin S-sickle cell anemia)
-Decrease of temperature
-Cardiovascular diseases
-Local disorder in circulation

5. Decrease utilization of oxygen by the tissue (histotoxic hypoxia)

-enzyme blocade of respiratory circle (poisoning)

- e.g. Cyanid poisoning – cyanid inhibits cytochromoxidase;
treatment: methylen blue or nitrites (methemoglobin + cyanid=cyanmetHg=nontoxic compound

-lower capacity of cells for utilization of oxygen (deficit of vitamins)

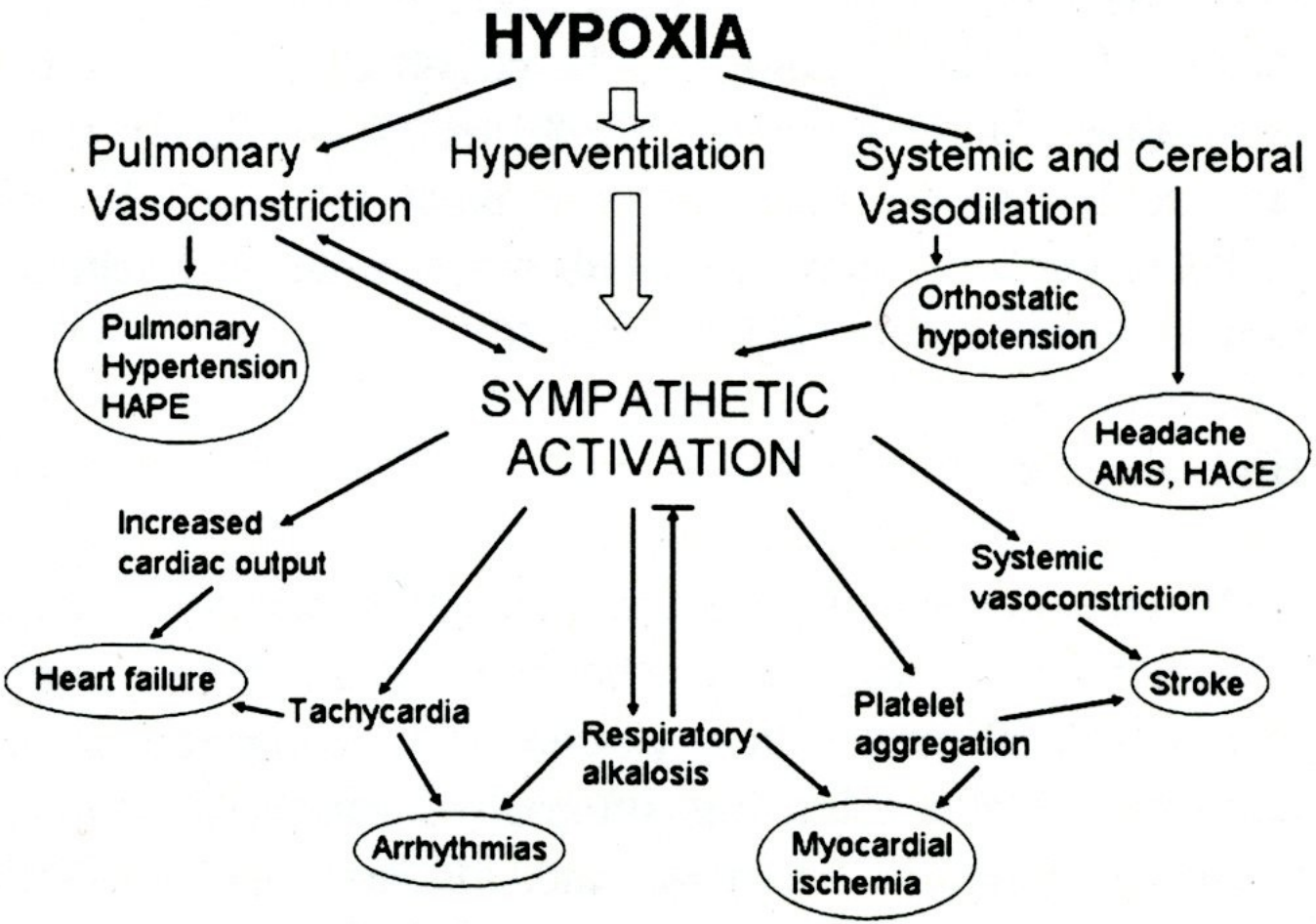


Fig. 3 Important physiological and pathophysiological effects during acute exposure to hypoxia and their potential associations with clinical conditions (modified after Rimoldi et al. 2010 [32]). *AMS* acute mountain sickness, *HACE* high-altitude cerebral edema, *HAPE* high-altitude pulmonary edema

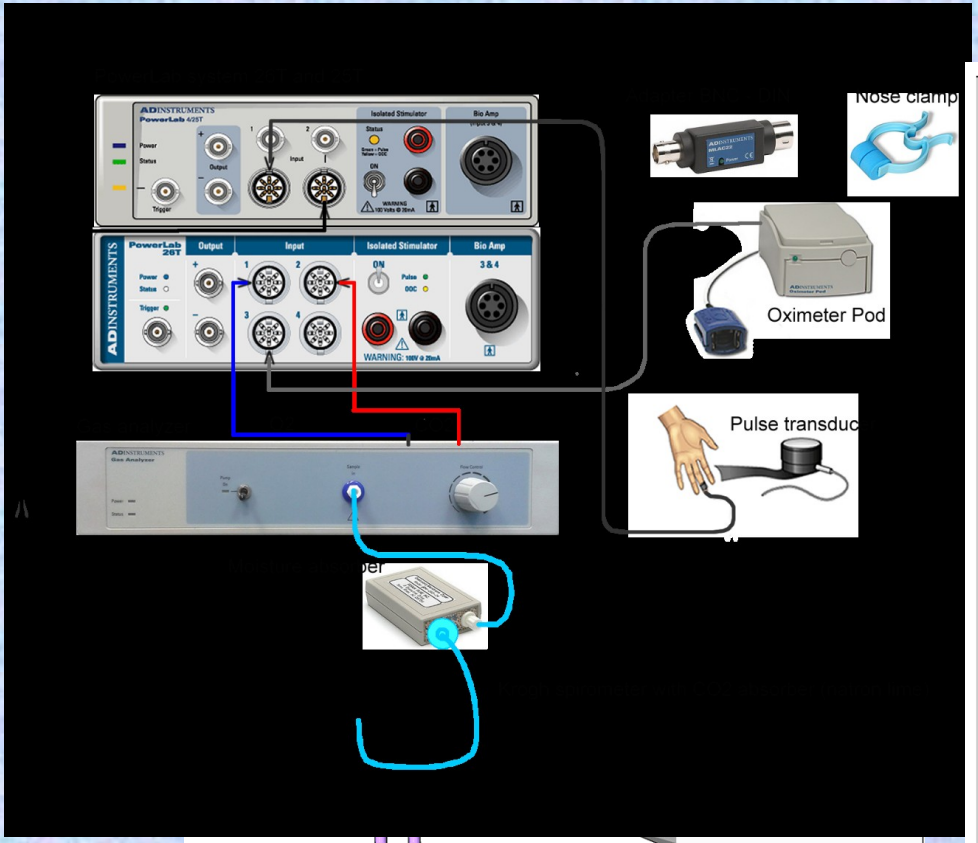
Experiment

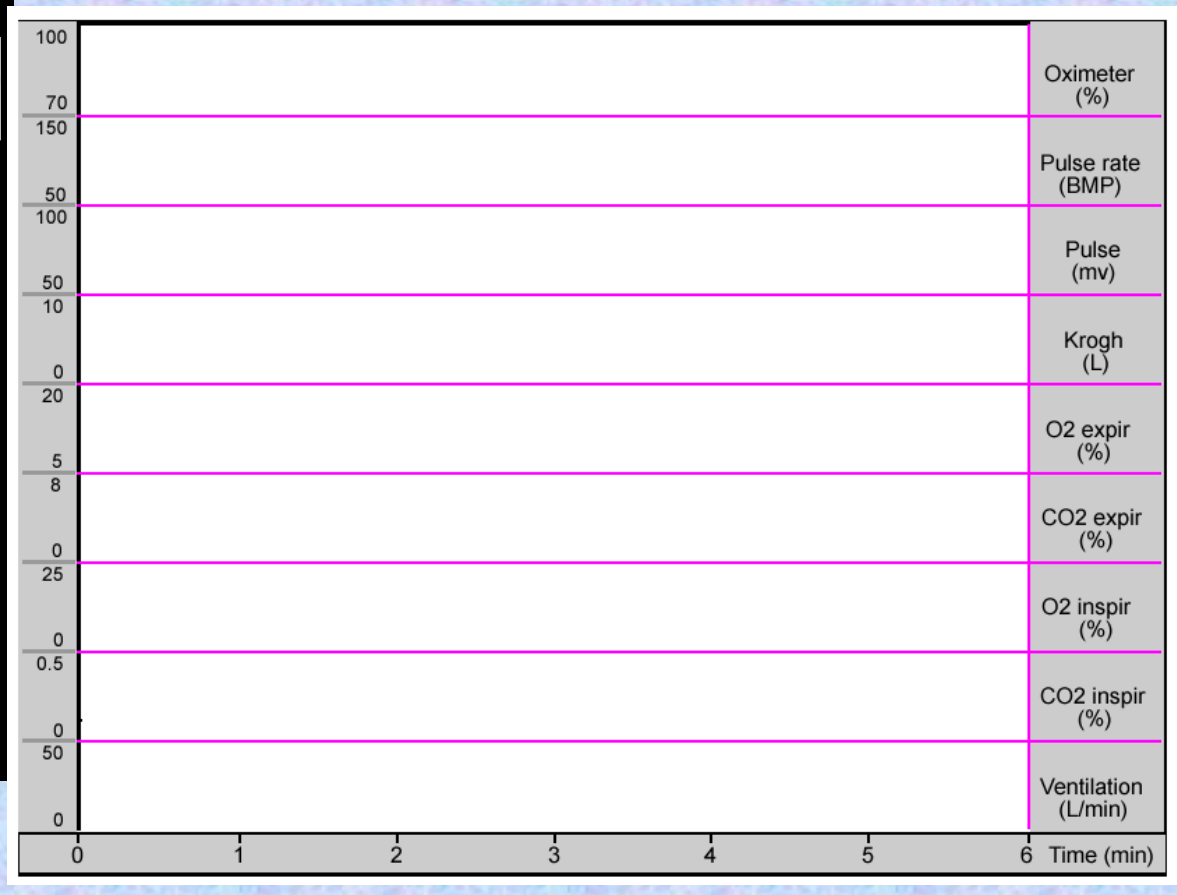
Hypoxic hypoxia – use the Krogh respirometer

Filling: ambient air
with CO_2 absorber (calcium hydroxide)

Bed with fur and pillow
I have no bow and arrow

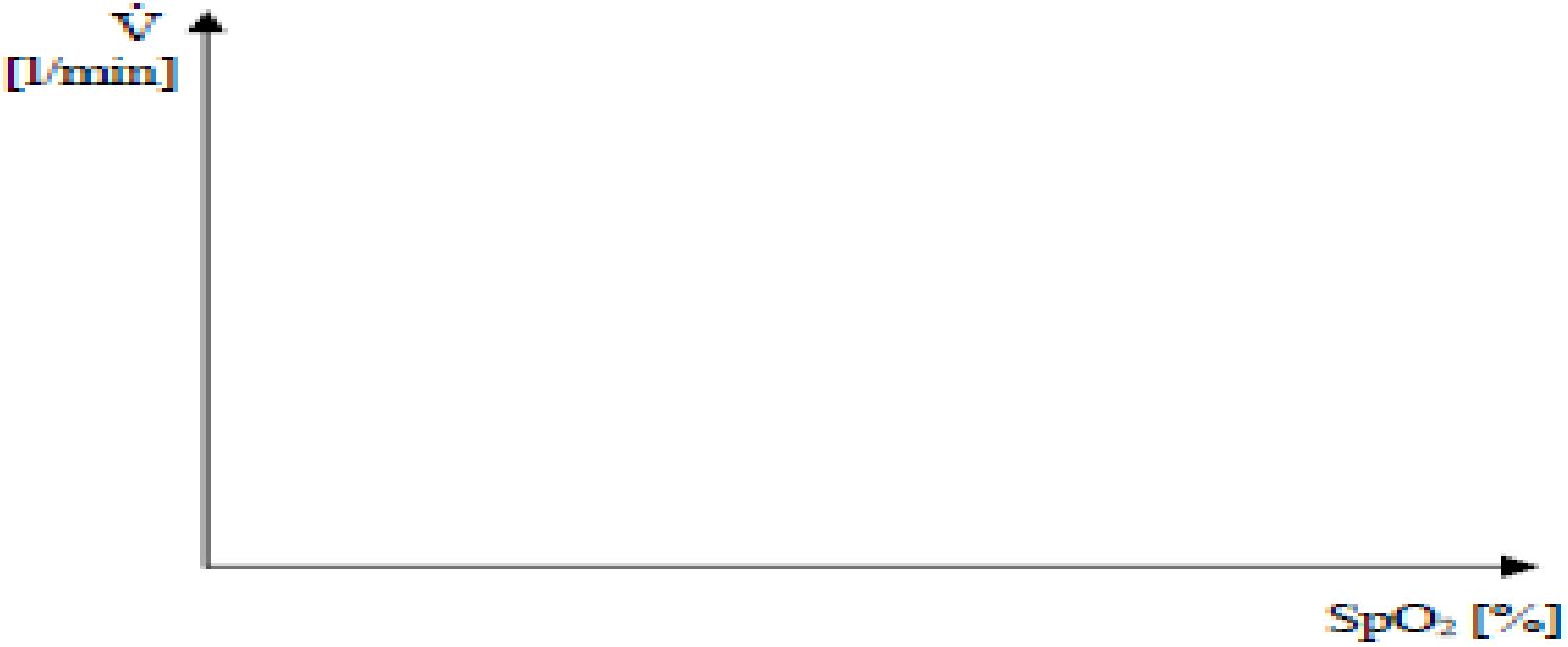
Hypoxia setup





Výsledky:

Hypoxie								
Osoba A	1.	2.	3.	4.	5.	6.	7.	8.
SpO_2 [%]								
$\dot{V}$ [l/min]								
Osoba B	1.	2.	3.	4.	5.	6.	7.	8.
SpO_2 [%]								
$\dot{V}$ [l/min]								



Hypoxic hypoxia

– during a trip to high mountains

e.g. with cable car to Mont Blanck

Effect of high altitude on arterial oxygen saturation
(numbers in parenthese are acclimatized value)

Altitude (m)	*barometric pressure (mmHg)*	*pO_2 in air (mmHg)*	*pCO_2 in alveoli (mmHg)*	*pO_2 in alveoli (mmHg)*	*arterial oxygen saturation (%)*
0	*760*	*159*	*40 (40)*	*104 (104)*	*97 (97)*
3 048	*523*	*110*	*36 (23)*	*67 (77)*	*90 (92)*
6 096	*349*	*73*	*24 (10)*	*40 (53)*	*73 (85)*
9 134	*249*	*47*	*24 (7)*	*18 (30)*	*24 (38)*
12 192	*141*	*29*			
15 240	*87*	*18*			

Breathing pure oxygen

altitude (m)	*barometric pressure (mmHg)*	*pCO2 in alveoli (mmHg)*	*pO2 in alveoli (mmHg)*	*arterial oxygen saturation (%)*
0	*760*	*40*	*673*	*100*
3 048	*523*	*40*	*436*	*100*
6 096	*349*	*40*	*262*	*100*
9 134	*349*	*40*	*139*	*99*
12 192	*141*	*36*	*58*	*84*
15 240	*87*	*24*	*16*	*15*

Work capacity at high altitude

	work capacity (compare with normal condition) (%)
Unacclimatized	*50*
Acclimatized for 2 months	*68*
Native living at 4 023 m but working at 5 182 m above sea level	*87*

High altitude hypoxia – mountain sickness - mild step

CNS	*disorientation*
GIT	*nausea*
Sensitivity	*headache*
Respiration	*increase*
BP	*increase*
HR	*increase, arrhythmias*
muscle	*loss of co-ordination*

High altitude hypoxia – middle step

CNS	*dimness of vision, vertigo, anxiosity*
GIT	*nausea*
Sensitivity	*chest pain*
Respiration	*apnoe*
BP	*increase*
HR	*decrease, irregulary*
muscle	*spasmus*

High altitude hypoxia – severe step

CNS	*coma*
GIT	*nausea, vomiting*
Sensitivity	*chest pain*
Respiration	*Cheyn-Stokesovo dýchání*
BP	*drop*
HR	*decrease*
Muscle	*muscle weakness*

Travelling by aircraft

<u>High risk for patients with:</u>

- ***Concentration of hemoglobin above 60 %***
- ***Atherosclerosis - severe step***
- ***Cardial insuficiency***
- ***Respiratory insuficiency***
- ***Hypertension - untreated (BP ower 200/100)***

(On board aicraft is pressure as on 2000 m above see level)

Influence on SBP and DBP

- ***lower pO_2 stimulated sympaticus***
- ***increase periphery resistance***
- ***decrease stroke volume***
- ***decrease pulse pressure***
- ***decrease perfusion in tissues***
- ***redistribution of blood in circulation***
- ***increase of position of diaphragma***

(decrease hemodynamics and respiration)

The traveling by craft is risk for patients with

- cardio – vascular diseases

- tromb – embolic diseases

Toxicity of oxygen

The toxicity seems to be due to the production of the superoxid anion and H_2O_2

Causes: - *inability to bind CO_2 in venous blood*
- *development of CO_2 is more difficult due to toxic pulmonary oedema*

Critical values: > 40 kPa (300 mmHg) ..dependent on time

Toxicity of oxygen

Exposure – 8 hours:- *Respiratory passages became irritated*

- Substernal distress

- Nasal congestion

- Sore throat

- Cough

- 24-48 hours:

- damage of lungs – decrease production of surfactant

TOXICITY of OXYGEN

Recommendation:

100 % - give discontinuosly