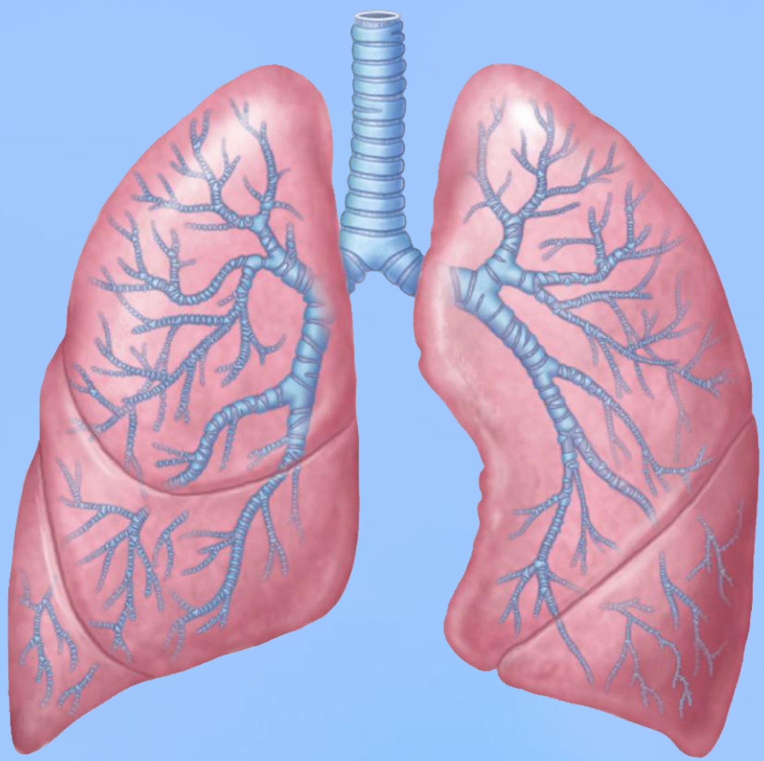
10 Effects of exercise on the respiratory system



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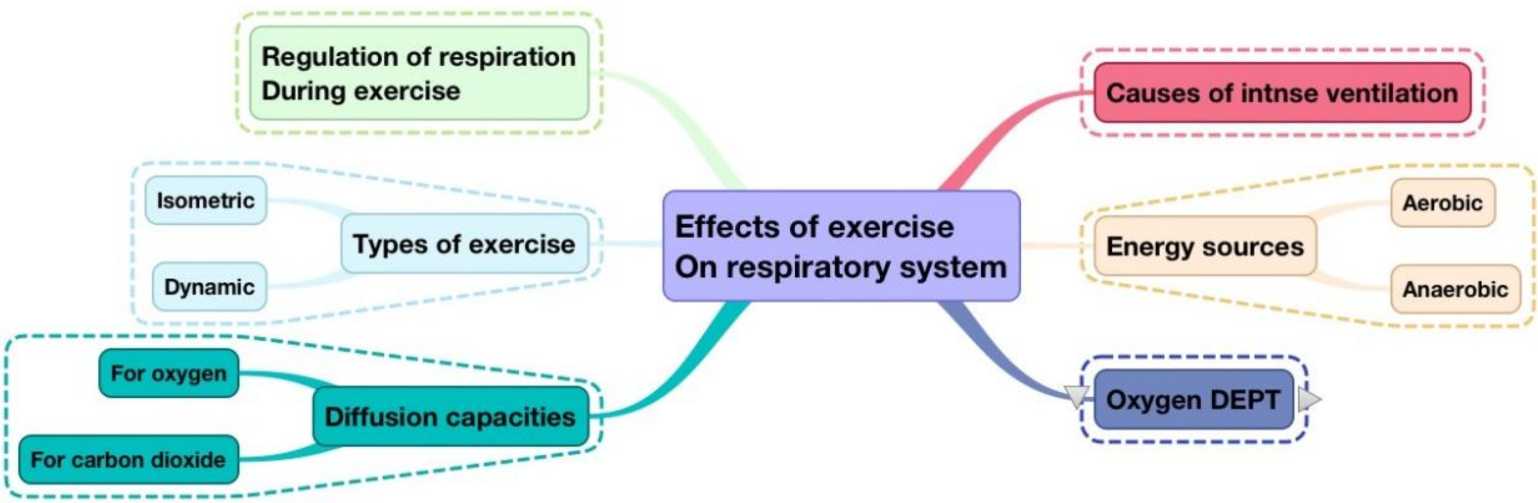
Respiratory Block

Objectives:

- Understand the difference between dynamic and isometric exercise.
- Describe the effects of moderate and severe exercise on oxygen consumption (Vo2 Max) , and ventilation volumes.
- Describe the effects of exercise on arterial PO2, PCO2 and H+ ions.
- Define the diffusing capacity of the respiratory membrane, and its typical values at rest, and explain its changes in exercise.
- Explain causes of hyperventilation in exercise.

Mind Map:



Effect of exercise on the respiratory system

- The blood gases do not always have to become abnormal for respiration to be stimulated in exercise (so, we hyperventilate to prevent any changes in PO_2 -PCO_2-H^+, not because there is a decreasing or increasing in these parameters)

- Instead, respiration is stimulated mainly by neurogenic mechanisms during exercise.

Isometric excercise

- no visible movement at the joint
- the length of the muscle does not change and there
- strengthening the muscles without stress on the joint
- drives up blood pressure and **Valsalva-Maneuver**[1].

Dynamic exercise

- increase strength throughout the full rang of motion
- Blood circulation, strength, and endurance are improved by these continuous movements
- Eg. swimming, walking

NOTE

The Valsalva maneuver is performed by attempting to exhale against a closed airway. This can be done by keeping the mouth closed and pinching the nose .while trying to breath out.

Regulation of respiration during exercise

When we exercise more oxygen is needed by the working muscles and more carbon dioxide must be removed from the muscle

As a result:

- **our rate of breathing increases**
- **we increases the blood flow through the lungs**
- **we increases the oxygen taken up and used by the body**

Oxygen used during exercise can be up to twenty times a person's normal oxygen uptake.

- Normal oxygen consumption **(Vo2 Max)** for a young man at rest is about 250 ml/min.

  However, under maximal conditions!
- Untrained average male 3600ml/min
- Athletically trained average male 4000ml/min
- Male marathon runner 5100ml/min

In strenuous exercise O_2 consumption and CO_2 formation may **increase 20 folds**, but alveolar ventilation increases almost exactly in step with the increased levels of metabolism

Therefore the arterial PO_2, PCO_2, PH all remain almost exactly normal

Diffusion capacity of the respiratory membrane

Is the volume of gas that diffuses through the membrane each minute for a pressure difference of 1mmHg.

Diffusing capacity for oxygen

Diffusing Capacity for oxygen at rest: **21ml/min/mmHg**

Even if the oxygen pressure difference across the respiratory membrane is 11mmHg

11 x 21= 230ml O2 diffusing through the membrane/min.

During rest tissues consume 250ml O2/min

O2 pressure difference x Diffusing capacity for O2 at rest = O2 diffusing through the membrane/min

Changes In the oxygen diffusing capacity during exercise

65ml/min/mmHg (This is the diffusion capacity when the pressure difference= 1 during exercise)

- increase in pulmonary blood flow (phase I or the cardio-dynamic phase)
- Before a rapid increase in oxygen consumption related to muscle extraction of O2 (phase II or the oxygen uptake kinetic phase)
- Before reaching steady-state (phase III) if the work load does not result in the accumulation of blood lactate.

Diffusing capacity for carbon dioxide

O2 vs CO2

- It diffuses 20 times greater than oxygen due to greater diffusion coefficient which is 20 times that for oxygen.

At rest

- Diffusion capacity for carbon dioxide is 400 ml/min/mmHg.

during exercise

- During exercise 1200 to 1300 ml/min/mmHg.

Diffusion is a rapid process and during exercise the circulation process becomes faster, so what makes the diffusion process works effectively?

During exercise the oxygen requirement increased 20 times, and cardiac output increased and so the time blood remained in the pulmonary capillaries becomes less than half normal despite the fact that additional capillaries open up.

But the blood is almost completely saturated with oxygen when it leaves the pulmonary capillaries.

Reasons for this are as follow

The diffusing capacity for oxygen increases almost three fold during exercise, this results mainly from increasing numbers of capillaries participating in the diffusion, and a more even V/Q ratio all over the lung.

At rest the blood normally stays in the lung capillaries about three times as long as necessary to cause full oxygenation. Therefore, **even with shortened time of exposure in exercise, the blood is still fully oxygenated or nearly so.**

WHAT CAUSE INTENSE VENTILATION DURING EXERCISE?

- Neural signals from the motor areas of the brain to the respiratory center.
- The joint proprioceptors
- Body temperature (hypothalamus).
- Possibility that the neurogenic factor for control of ventilation during exercise is a learned response.
  - like when the player see the court that he used to play and train on it, he will start to hyperventilate.

<u>During maximal effort :</u>

Pulmonary ventilation at maximal exercise is **100-110L/min**

Maximal breathing capacity **150-170L/min**

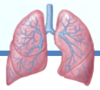
Maximal Breathing Capacity: is about 50 % greater than the actual pulmonary ventilation during maximal exercise. to giving athletes extra ventilation for example:

(1) exercise at high altitudes ,
(2)exercise under very hot conditions, and
(3) abnormalities in the respiratory system.

Anaerobic energy sources

- 1-Phosphocreatine →Creatine + PO3
- 2- Glycogen →Lactic acid ↓

ATP→ ADP+ AMP
Energy for muscle contraction



NOTE

Anaerobic system: uses stored molecules to get energy for limited time.

Aerobic system

Food + O_2 → CO_2 + H_2O + Urea

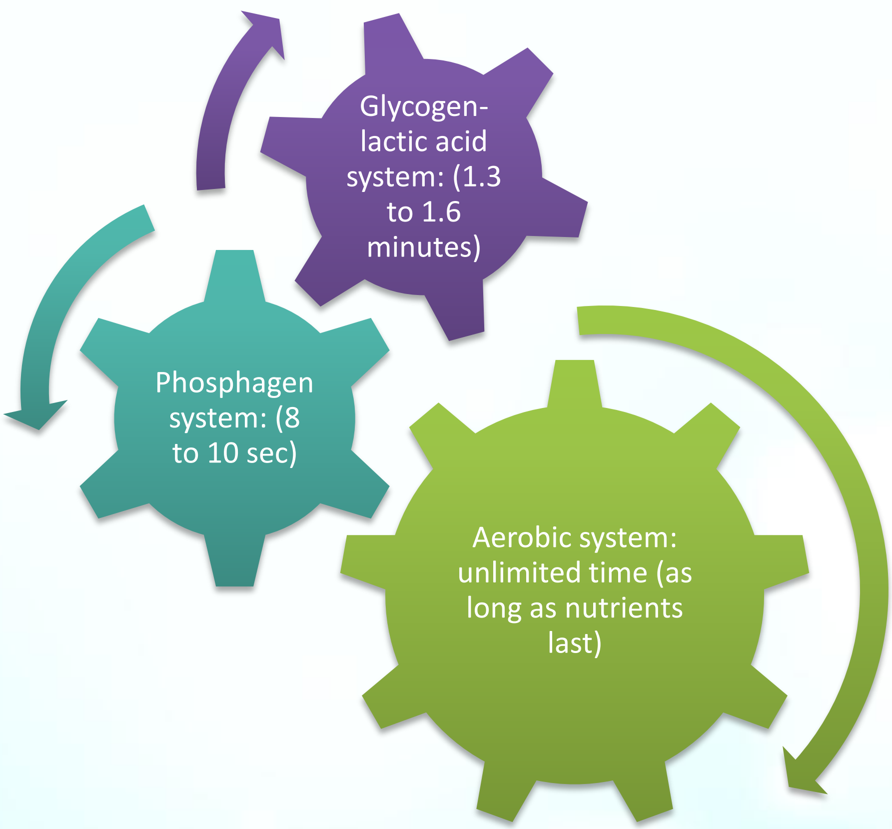
Glucose

Fatty acid

Amino acid

The phosphagen energy system

The combined amounts of cell ATP and cell phosphocreatine are called the phosphagen energy system.	These together can provide maximal muscle power for 8 to 10 seconds, almost enough for the 100-meter run.	Thus, the energy from the phosphagen system is used for maximal short bursts of muscle power.



Realationship between excercise energy source &

Oxygen DEPT

Oxygen Debt Is the Extra Consumption of Oxygen after Completion of Strenuous Exercise

(about 11.5 liters)

You will develop oxygen debt after about 5 minutes or more of constant exercise. This is the point when the exercise becomes ANAEROBIC (without the use of oxygen) and which has to be paid back. If the exercise is just AEROBIC (with oxygen) there will be no oxygen debt.

Q1: Diffusing capacity for oxygen at rest:

A. 400ml/min/mmHg
B. 21ml/min/mmHg
C. 65ml/min/mmHg
D. 1200ml/min/mmHg

Q2: Changes in the oxygen diffusing capacity during exercise:

A. 400ml/min/mmHg
B. 65ml/min/mmHg
C. 25ml/min/mmHg
D. 1200ml/min/mmHg

Q3: Diffusing capacity for carbon dioxide, it diffuses:

A. 40Times greater than oxygen
B. 30Times greater than oxygen
C. 20Times greater than oxygen
D. 10Times greater than oxygen

Q4: Combined amounts of cell ATP and cell phosphocreatine are called the:

A. Aerobic system
B. Glycogen–lactic acid system
C. Phosphagen energy system
D. Anaerobic system

Q5: The energy from the Phosphagen system is used for maximal:

A. Long bursts of muscle power.
B. Short bursts of muscle power

Q6: During exercise the body need:

A. More Co2, more O2 Removed
B. More O2 , more Co2 Removed
C. More CL , more O2 Removed
D. More O2 , more CL Removed

Q7: Which one makes a long exercise Duration and energy source?

A. Phosphagen System
B. Glycogen–lactic acid system
C. Anaerobic system
D. Aerobic System

Q8: Which of the following is the amount of Oxygen DEPT?

A. 11.5 L
B. 10.5 L
C. 12.5 L
D. 10 L

Answers: 1-B 2-B 3-C 4-C 5-B 6-B 7-D 8-A

Summary

Effect of exercise on the respiratory system

Two types of exercise: 1- isometric exercise: No joint movement 2- Dynamic exercise: Wide range of movement	When we exercise, muscles need to take up more oxygen and remove more carbon dioxide	Oxygen consumption at rest is 250 ml\min and Carbon dioxide formation is 200 ml\min They may increase about 20-fold during exercise
Diffusion capacity fo O_2 at rest: **21ml/min/mmHg** Diffusion capacity of CO_2 at rest: **400ml/min/mmHg** **This means CO_2 diffuses 20 times more than O_2**	During maximal effort: Pulmonary ventilation at maximal exercise is **100-110L/min** Maximal breathing capacity is **150-170L/min**	**Oxygen Debt** Is the Extra Consumption of Oxygen after Completion of Strenuous Exercise (about 11.5 liters)

The lactate threshold (LT) is strongly correlated with ventilator:

http://www.youtube.com/watch?v=VBJ97oeyor0