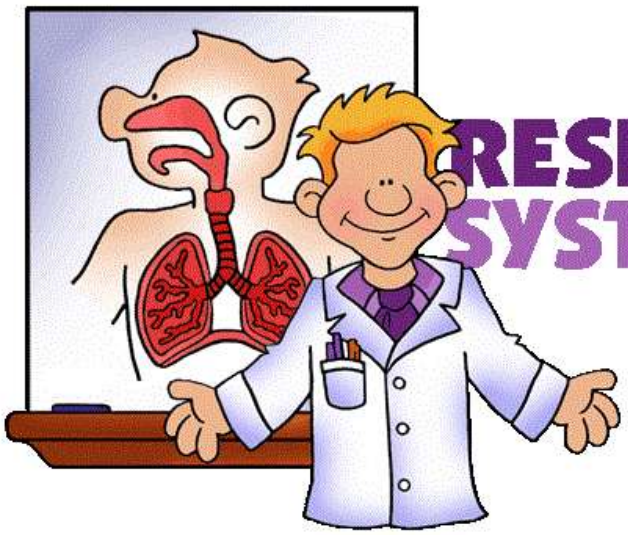
Physiology Team 432



10th Lecture

Effects of exercise on the respiratory system

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1434- 2013

Effects of exercise on the respiratory system

Objectives

By the end of this lecture the students should be able to: -

- Understand the difference between dynamic and isometric exercise.
- Describe the effects of moderate and severe exercise on oxygen consumption, and
- Ventilation volumes.
- Describe the effects of exercise on arterial PO_2, PCO_2 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.

The blood gases do not always have to become abnormal for respiration to be stimulated in exercise. Instead, respiration is stimulated mainly by neurogenic mechanisms during exercise.

Blood doesn't become abnormal during exercise

neurogenic mechanisms هو الذي يتحكم بزيادة التنفس

Regulation of respiration during Exercise

- In strenuous exercise O2 consumption and CO2 formation may increase 20 folds but alveolar ventilation increases almost exactly in step with the increased levels of metabolism.
- Therefore the arterial PO2, PCO2, PH all remain almost exactly normal.

*O_2 consumption = 250 ml/min

CO_2 formation =200 ml/min

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 = 21ml/min/mmHg

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

11x21= 230ml oxygen diffusing through the membrane each minute>

- **During rest tissues consume 250 ml O2 /min**

Changes in the oxygen- diffusing capacity during exercise = 65ml/min/mmHg

This is due to increased number of open pulmonary capillaries which was dormant, thereby increasing the surface area for gas exchange. In addition to increased alveolar ventilation.

Rest

- **O_2 =21ml/min/mmHg**
- **Co_2 =400ml/min/mmHg → 20×20=400**

Exercise

- **O_2 =65ml/min/mmHg**
- **Co_2=1200-1300ml/min/mmHg → 65×20=1300**

↑ Open pulmonary capillaries

↑ Alveolar ventilation

Diffusing capacity for carbon dioxide

- **It diffuses 20 times greater than oxygen due to greater diffusion coefficient which is 20 times that for oxygen**
- **Diffusion capacity for carbon dioxide 400ml/ min/mmHg**
- **During exercise 1200 to 1300ml/min/mmHg**
- **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

1- 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.

2- 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.

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**

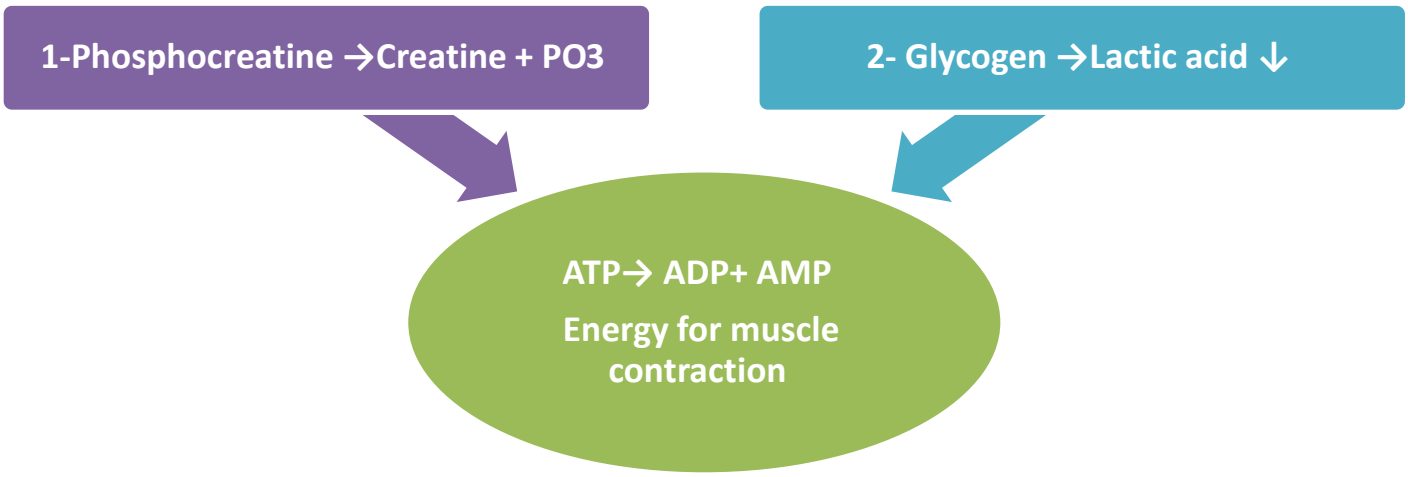
Oxygen used during exercise can be up to twenty times a person's normal oxygen uptake.

What cause intense ventilation during exercise?

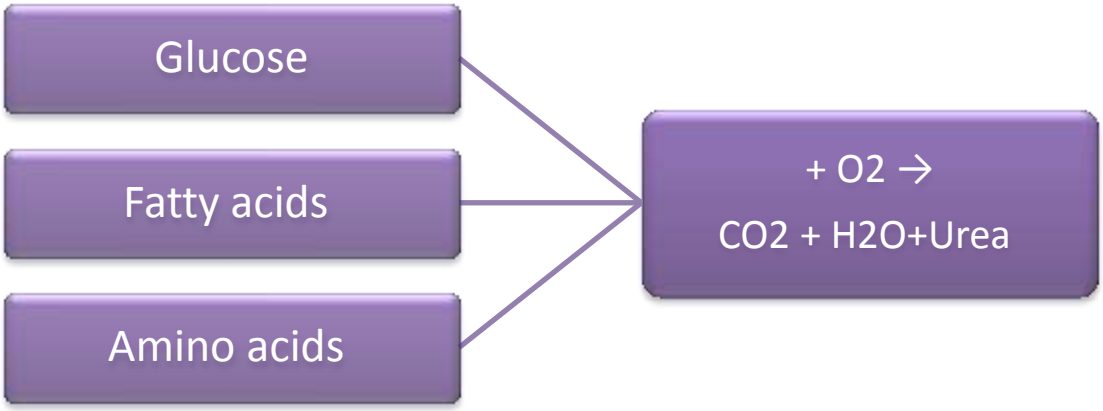
- The brain (motor areas).
- The joint proprioceptors
- Body temp (hypothalamus).
- Possibility that the neurogenic factor for control of ventilation during exercise is a learned response.

إستجابة ذهنية. زي لما واحد يتمرن كل يوم في النادي ، راح يرتبط في ذهنه إنه كل مرة يدخل النادي راح يرتفع مستوى التنفس عنده.

Anaerobic energy sources



Aerobic system



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.

Relation between exercise duration& energy source

Phosphagen system

8-10 seconds (100 m)

Sprinter

Glycogen-lactic acid system

1.3–1.6 minutes (400 m)

Swimmer

Aerobic respiration

Marathon runner

Unlimited time (15 Km)
(as long as nutrients last)

Oxygen Consumption and Pulmonary Ventilation in Exercise

- Normal oxygen consumption for a young man at rest is about 250 ml/min.
- However, under <u>maximal conditions</u>, this can be increased to approximately the following average levels:
  - Untrained average male غير مدرَّب → 3600 ml/min
  - Athletically trained average male رياضي مدرَّب → 4000 ml/min
  - Male marathon runner عداء ماراثون → 5100 ml/min

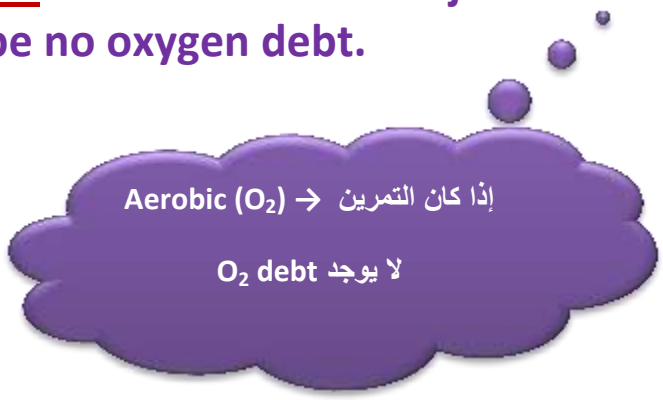
OXYGEN DEBT

Oxygen Debt Is the Extra Consumption of Oxygen after Completion of Strenuous Exercise (about 11.5 liters)

EXPLANATION

Oxygen debt is a physiological phenomenon which occurs when someone has consumed oxygen at a rate faster than it can be replaced, leading to a deficit in oxygen which causes increased respiration as the body attempts to replace the used oxygen. Classically, oxygen debt occurs when people exercise, which is why people breathe heavily after exercising

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.



GOOD LUCK