MEDICINE
KING SAUD UNIVERSITY

Physiology Team 436

Physical and Physiological Factors Affecting Sport Performance

Revised by
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Red: very important.
Green: Doctor's notes.
Yellow: numbers.
Gray: notes and explanation.

Physiology Team 436 – Musculoskeletal Block Lecture 8

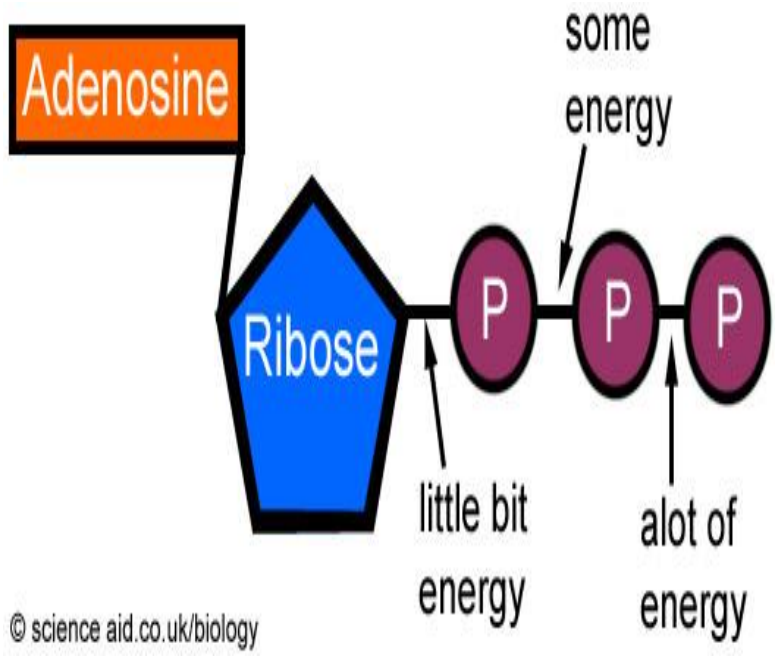
Lecture: If work is intended for initial studying.
Review: If work is intended for revision.

Objectives

1. Identify the muscle metabolic systems and the nutrients used in exercise
   - Adenosine triphosphate
   - Phosphocreatine-creatine system
   - Glycogen-lactic acid & aerobic system
2. Explain the recovery of the muscle metabolic systems after exercise and the phenomena of oxygen debt
3. Discus the effects of smoking on pulmonary ventilation in exercise.
4. Correlate between heart diseases and the athletic performance in old age.
5. Analyze the changes in body fluids and salts in exercise.
6. Interpret the effects of drugs on athletes.

Metabolic Pathways in Skeletal Muscle

- Adenosine triphosphate (ATP) is the only energy source used directly by muscles for contractile activities.
- The **demand** and the **mechanism** of ATP production vary according to the type of work done
- At rest, a muscle cell contains a small store of ATP, but it cannot rely on this ATP once it begins contracting (enough for 3 seconds) -> (It will finish quickly so we need to regenerate it)
- Muscle cell must get ready for ATP production to keep pace with* the increased rate of utilization.



* To keep pace with : لمواكبة

Energy for Muscle Contraction

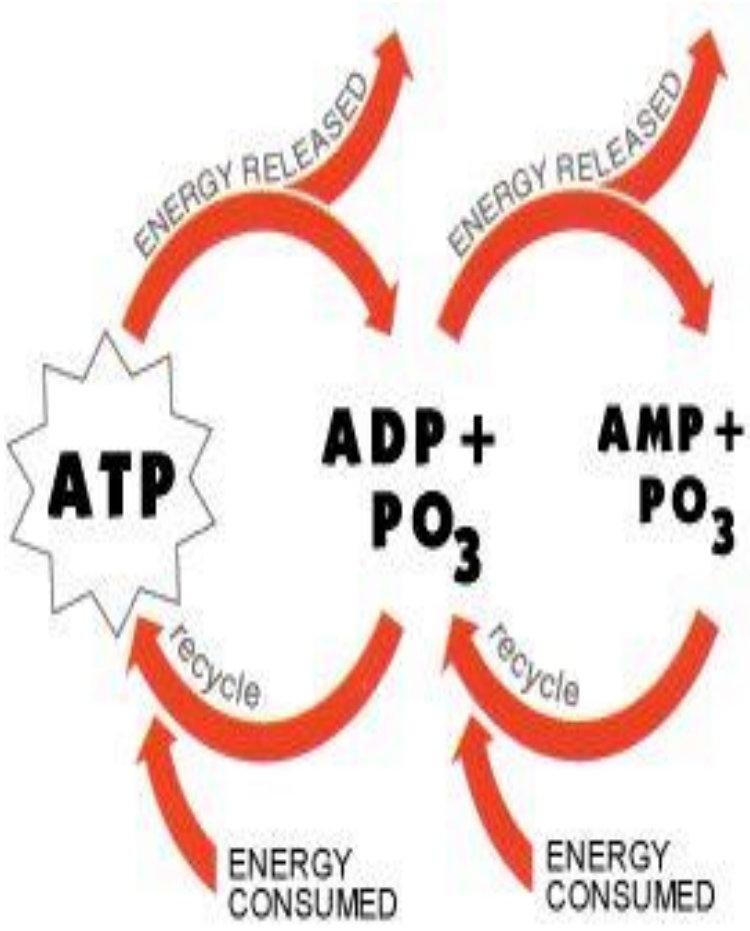
- Mitochondria in the muscle converts glucose, fatty acids, and amino acids into ATP:

(ATP = Adenosine Tri-Phosphate = Adenosine-PO3 ~ PO3 ~ PO3)

- Each of the last 2 high energy phosphate bonds in ATP stores 7300 calories per mole of ATP.
- All ATP stored in the muscle is sufficient for only 3 seconds (the number will vary) of muscle power. (Enough for one half of a 50-meter dash)

- So resting muscles must have energy stored in other ways:

1. Creatine Phosphate (CP) 2. Glycogen 3. Fat & amino acids.



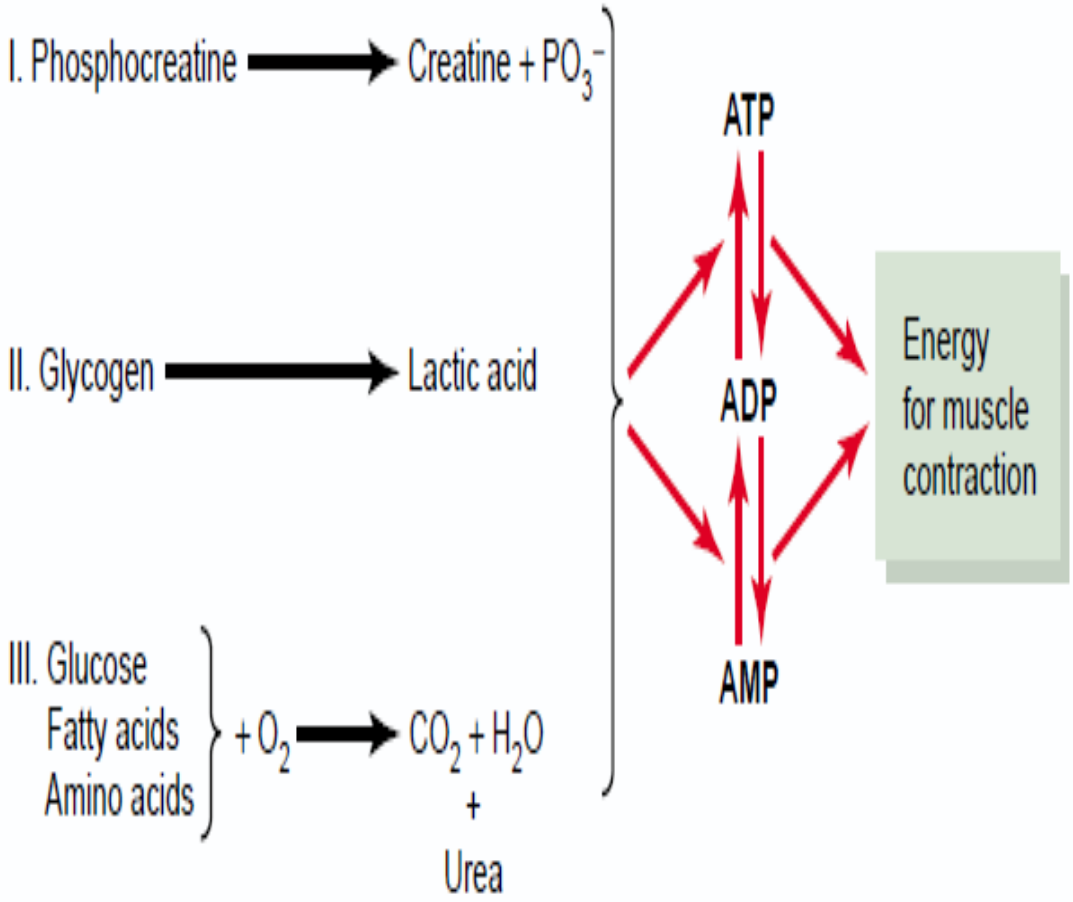
Muscle Metabolic System in Exercise

- There are 3 metabolic systems exceedingly (extremely, very) important in understanding the limits of physical activity, those are:-

Phosphocreatine-creatine system

Glycogen-lactic acid system

Aerobic system



ATP Regeneration

- As we begin to exercise, we almost immediately use our stored ATP within a few seconds

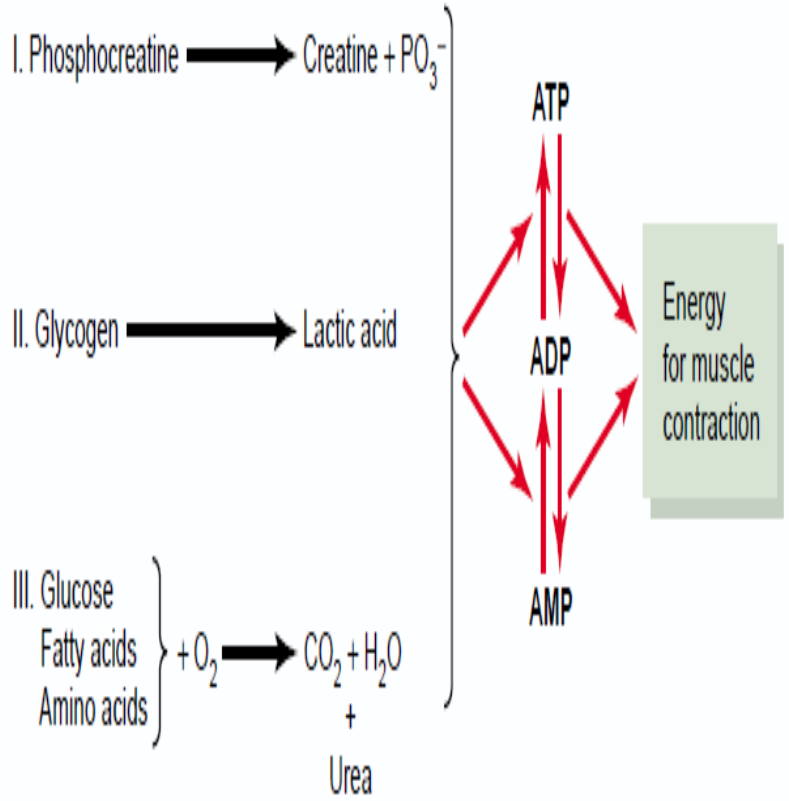
ATP is regenerated from ADP by:

1) Direct phosphorylation of ADP by **creatine phosphate** (CP) (take the phosphate and turn ADP to ATP)

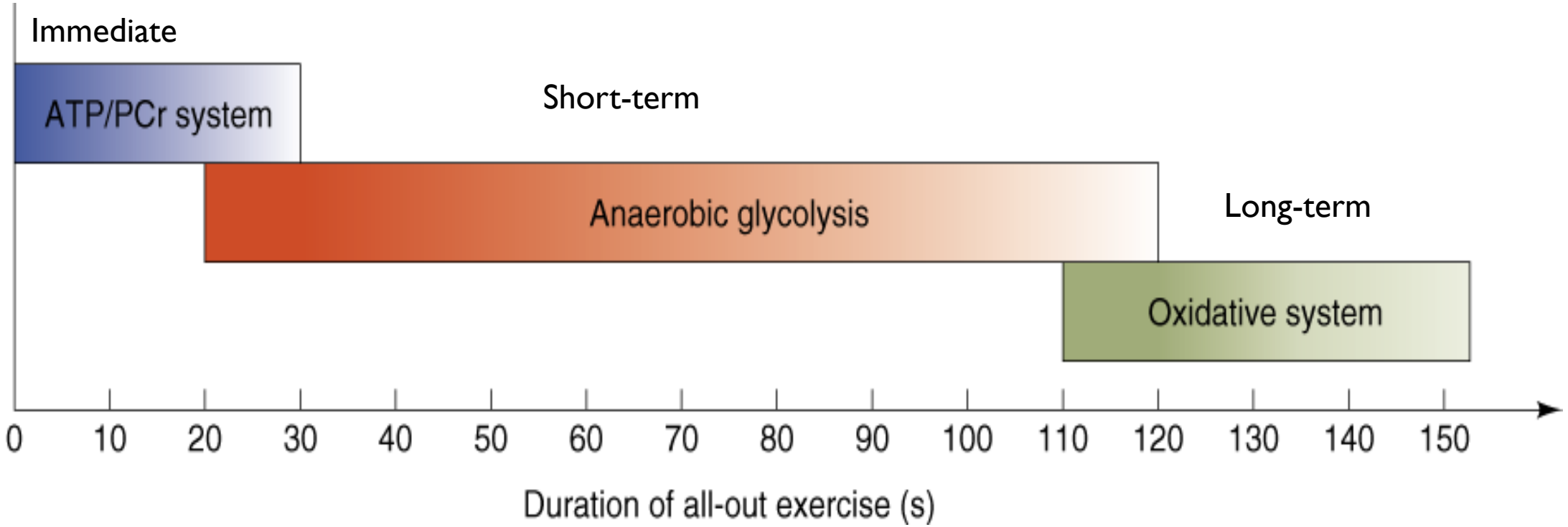
2) Anaerobic pathway (glycolysis → lactic acid)

3) Aerobic respiration of fatty acids in the mitochondria (slow, little intensity)

Fast and limited

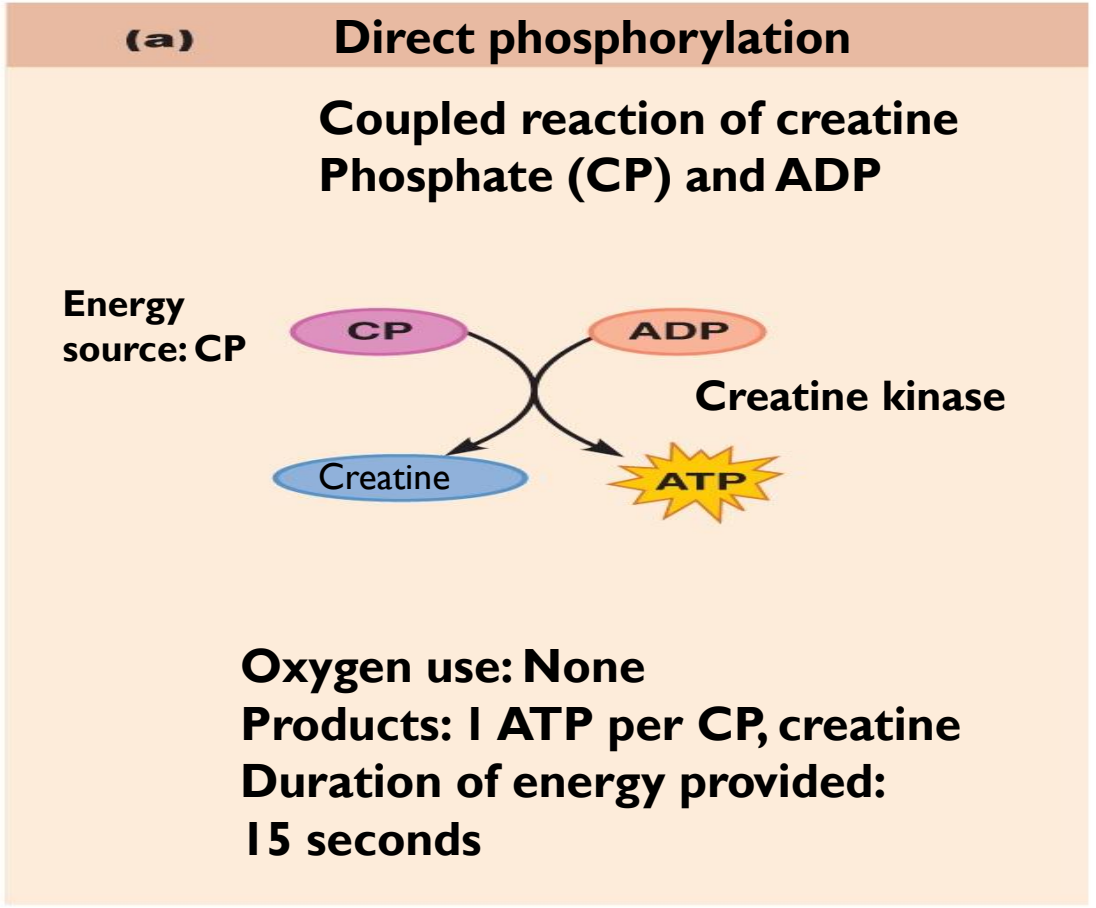


Interaction of Energy Systems



1-Phosphocreatine-creatine System (Creatine Po3):

- CP: Contain high energy phosphate bond has 10,300 calories/mole
- Most muscle cells have 2-4 times as much CP as ATP
- Energy transfer from CP to ATP occurs within a small fraction of a second.
- Energy of muscle CP is immediately available for contraction just as stored energy of ATP.
- Product: 1 ATP



Phosphagen Energy System:

- Formed of combined amounts of cell ATP + CP
- Together provide maximal muscle power for 8-10 seconds

(enough for 100 meter run)

- Energy of phosphagen system is useful for maximal short bursts of muscle power (8-10 seconds).

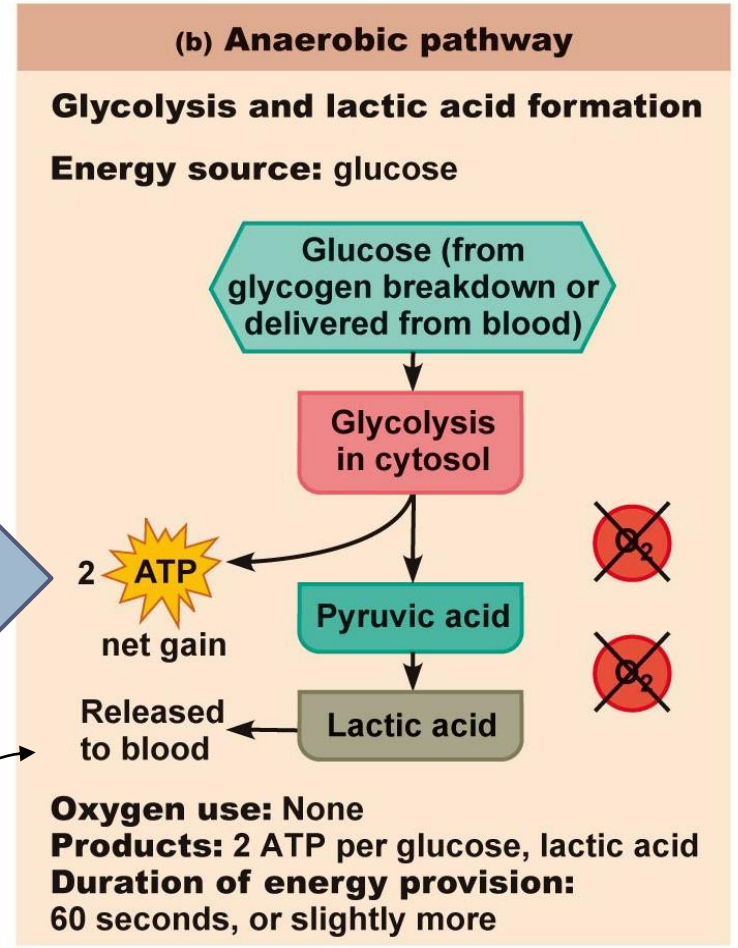
(Severe exercise for short duration)

2- Anaerobic Glycolysis (Glycogen-Lactic Acid System) Without Oxygen:

- Is the primary energy source for peak (severe) muscular activity. It provides 1.3-1.6 minutes of maximal muscle activity
- The process of anaerobic metabolism can maintain ATP supply for about 45-60s.
- Source of energy:
- Carbohydrate (glycolysis)
- Products: 2 ATP & Lactate

•Glycogen → Glucose → 2 pyruvic acid → Produces 2 ATP molecules per molecule of glucose + 2 NADH

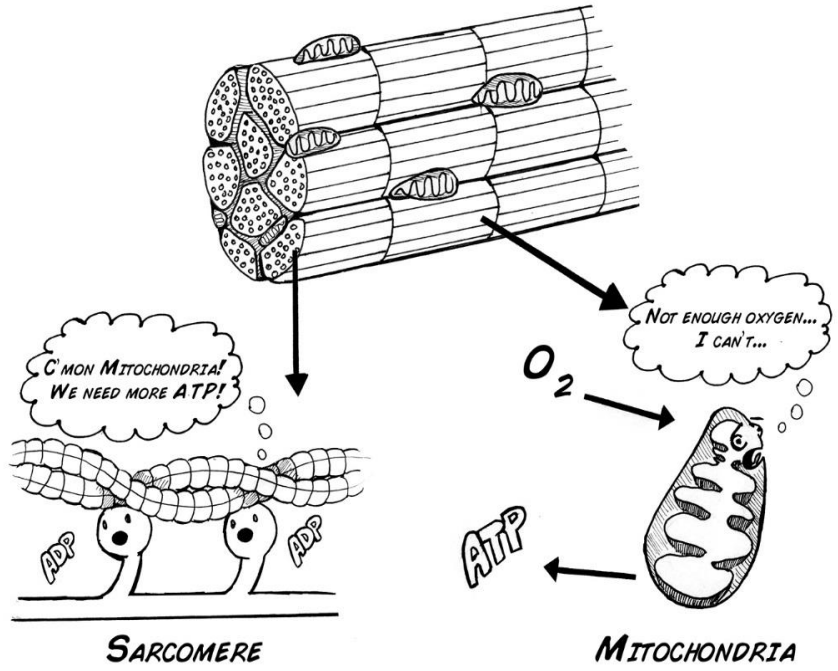
•2 Pyruvic acid → 2 lactic acid (2 NAD^+) → Lactic acid diffuses out of muscles→blood→ taken by the liver → Glucose (by gluconeogenesis) →blood → taken by the muscle again



Anaerobic Glycolysis (Glycogen-Lactic Acid System)

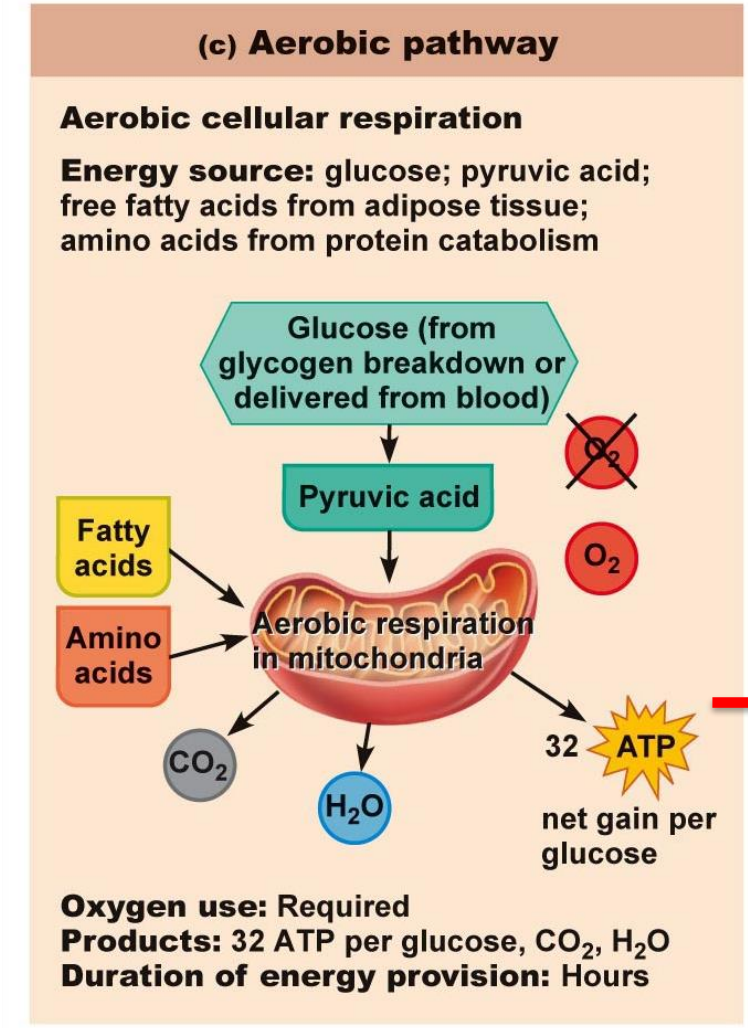
- Anaerobic metabolism is inefficient (غير فعال)… Why?
  1- Large amounts of glucose are used for very small ATP returns.
  2- Lactic acid is produced whose presence contributes to muscle fatigue.
- Which type of sports use anaerobic metabolism?
  -Sports that require bursts of speed and activity like:

1- basketball.
2- tennis.



3- Aerobic Metabolism (With Oxygen):

- Primary energy source of resting muscles:
  - to convert glucose into glycogen
  - to create energy storage compounds as CP. نعيد تكوينه
- during rest and light to moderate (average) exercise aerobic metabolism contributes 95% of the necessary ATP.
- It breaks down fatty acids, pyruvic acid (made via glycolysis), and amino acids
- Produces 34 ATP molecules per glucose molecule.



CO_2, H_2O & ATP

- Source of Energy:

1-Fatty acids (mainly) → 2- Carbohydrates → 3- Amino acids

Comparing the Energy Supply of the 1. Phosphagen, 2. Anaerobic, and 3. Aerobic Systems

ATP generation per minute are the following:

	Moles of ATP/min
Phosphagen system	4
Glycogen-lactic acid system	2.5
Aerobic system	1

لاحظ ان مولات النظام القصير اعلى نظام لأن لديه طاقة انفجارية تنتهي بسرعه.(مثل القفز بشكل مفاجئ).

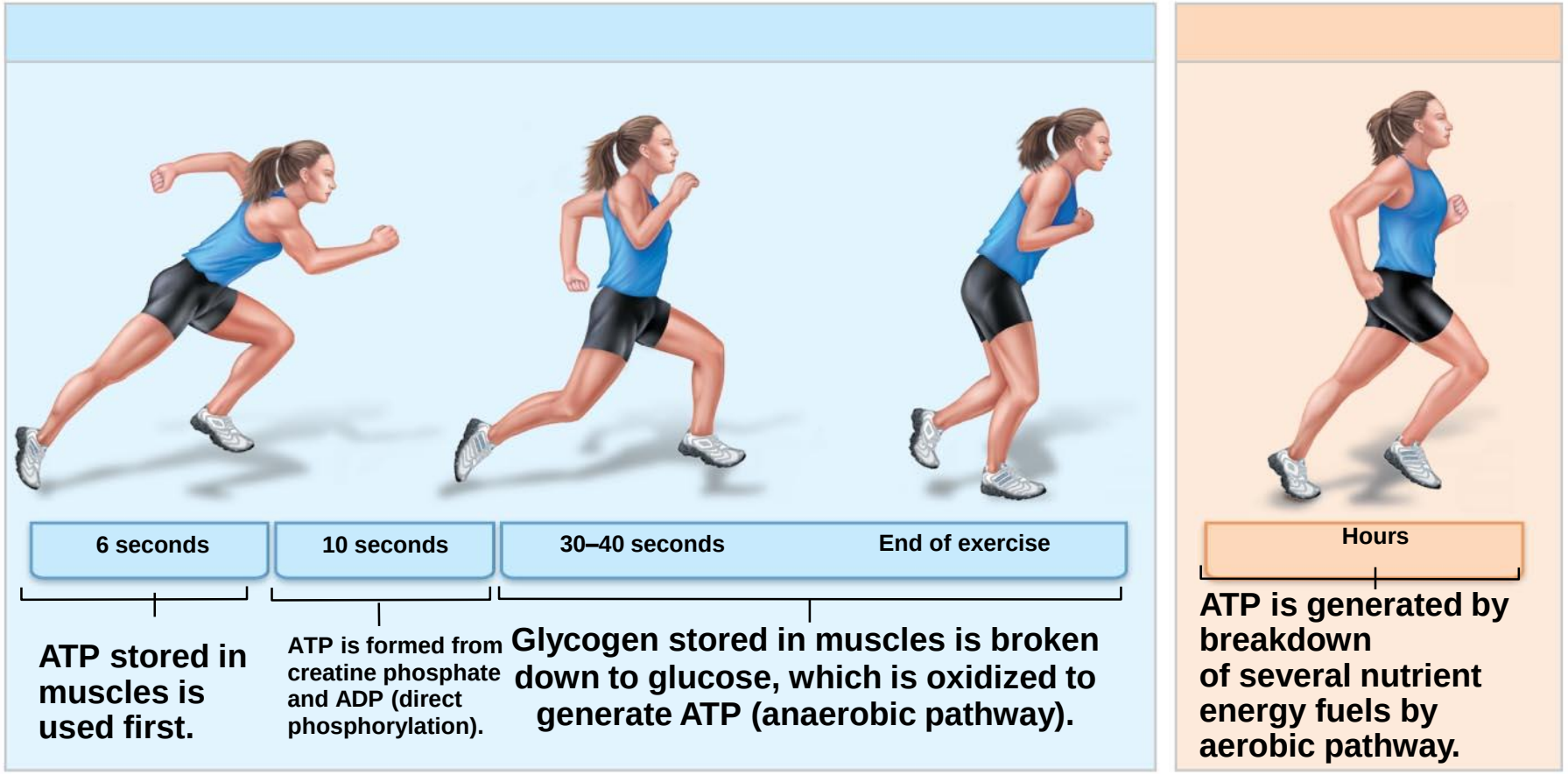
الطاقة متوسطة

الطاقة الاقل ولكنها مستمرة.

When comparing the same systems for endurance, the relative values are the following:

	Time
Phosphagen system	8-10 seconds
Glycogen-lactic acid system	1.3-1.6 minutes
Aerobic system	Unlimited time (as long as nutrients last)

Comparison of Energy Sources Used During Short-Duration Exercise and Prolonged-Duration Exercise



Extra From Team435

System	Power (rate of ATP production)	Capacity (total ability to produce ATP)	Fuels Used
phosphagen system	very high	very low	creatine phosphate stored ATP
glycolysis	high	low	blood glucose muscle & liver glycogen
aerobic system	low	very high	blood glucose muscle & liver glycogen adipose & intramuscular fat

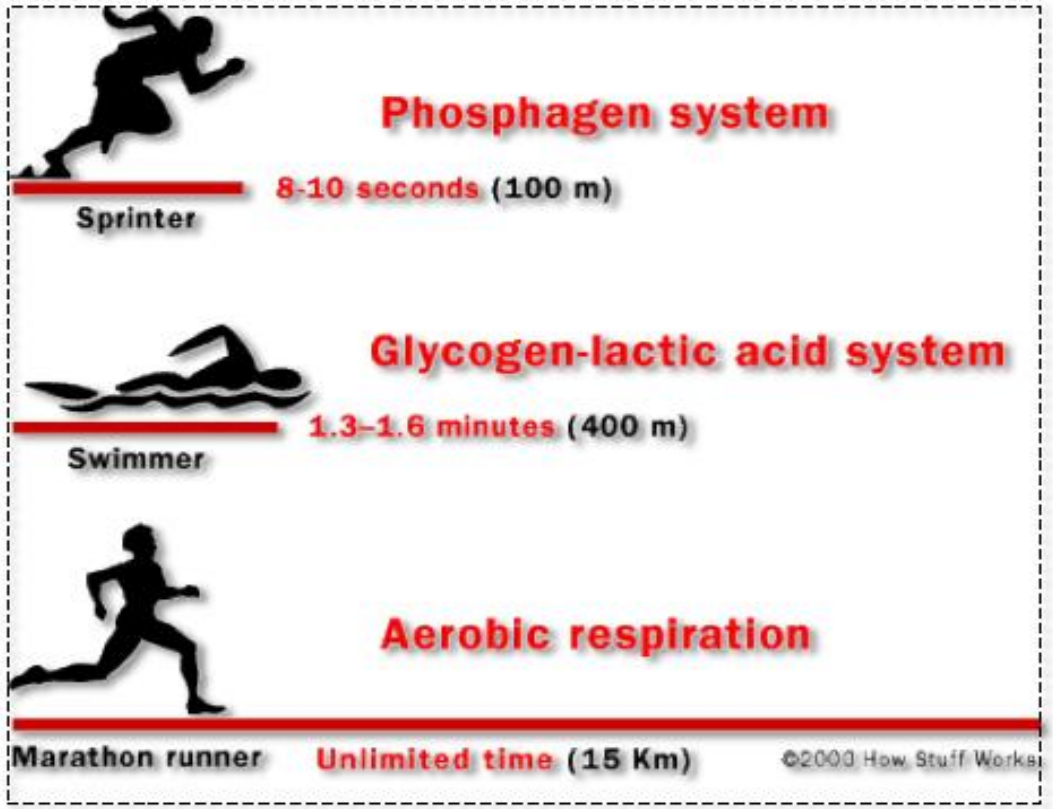


Table 84–1

Energy Systems Used in Various Sports

Phosphagen system, almost entirely
- 100-meter dash
- Jumping
- Weight lifting
- Diving
- Football dashes

Phosphagen and glycogen-lactic acid systems — Both
- 200-meter dash
- Basketball
- Baseball home run
- Ice hockey dashes

Glycogen-lactic acid system, mainly
- 400-meter dash
- 100-meter swim
- Tennis
- Soccer

Glycogen-lactic acid and aerobic systems — Both
- 800-meter dash
- 200-meter swim
- 1500-meter skating
- Boxing
- 2000-meter rowing
- 1500-meter run
- 1-mile run
- 400-meter swim

Aerobic system
- 10,000-meter skating
- Cross-country skiing
- Marathon run (26.2 miles, 42.2 km)
- Jogging

مهم تعرفون الجسم اي سستم يستعمل خلال رياضة معينة و التفرقة بينهم لكن عدد الامتار بس مروا عليها مو لازم تحفظوها

Recovery of Muscle Metabolic Systems After Exercise

Energy	
	from CP reconstitutes ATP.
	from glycogen-lactic acid system reconstitutes the phosphagen system (CP+ATP).
	from oxidative metabolism of aerobic system reconstitutes(يعيد تكوين) all other systems: glycogen-lactic acid system + CP+ ATP.

بإختصار: ATPs يعاد تخزينه في العضلات من Glycogen lactic ومن oxidative metabolism وراح ترجع مره ثانية.

كل واحد يرجع اللي قبله.

Lactic acid causes fatigue so it should be removed by:

1-portion (small amount) converted into pyruvic acid that is oxidized by all body tissues.

2-The remaining is changed into glucose in the liver to replenish glycogen stores of muscles.
(lactic acid is an energy source).

Recovery of Aerobic System After Exercise (Oxygen Debt)

- It is the amount of extra O_2 that must be taken after exercise to restore the muscles to the resting conditions.

- When a person stops exercising, the rate of oxygen uptake does not immediately return to pre-exercise (Normal) levels, it returns slowly. (the person continues to breathe heavily –hyper ventilating- for some time afterward).

- This extra oxygen is used to repay the **oxygen debt** incurred during exercise.

Oxygen Debt :
كمية الأوكسجين اللازمة عشان يرجع الجسم لحالته الطبيعية بعد النشاط البدني
اذا كان الشخص رياضي رح تتم العلمية بسرعة ويسترجع الاكسجين اسرع والعكس

توضيح:
لما الشخص يسوي نشاط بدني عالي , راح يستهلك كمية كبيرة من الأوكسجين الموجودة بالجسم. ولما يوقف هذا النشاط البدني , راح يزيد معدل التنفس بكمية أكبر ويزيد عشان يعوض الأوكسجين اللي أستهلك, ويرجع العضلات لحالتها الطبيعية (recovery).

Oxygen Debt

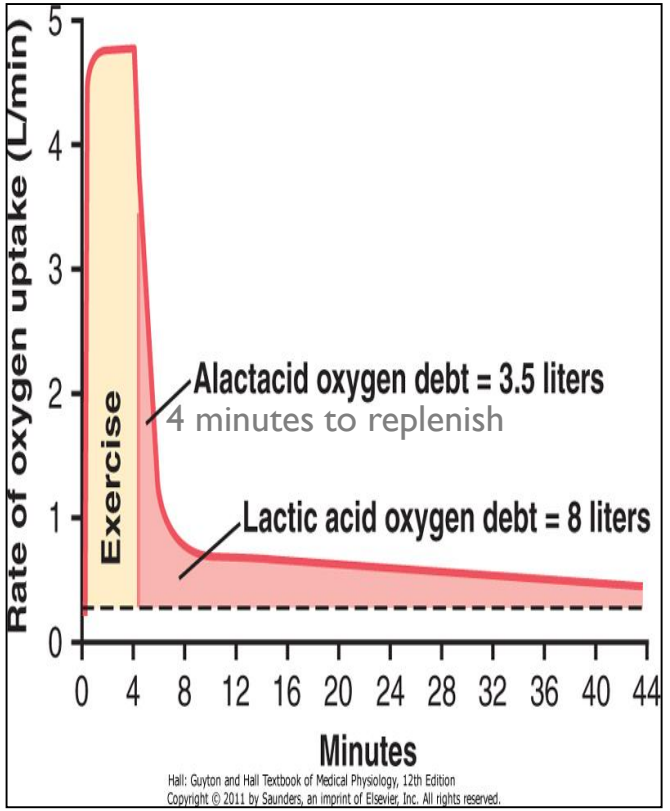
- The body normally contains about 2 liters of stored oxygen that can be used for aerobic metabolism.

- These 2 liters consist of (0.5 L in lungs + 0.25 L dissolved in body fluids + 1.0 L combined with Hb + 0.3 L stored in muscle myoglobin).

  These 2 liters are used within a minute of heavy exercise or for aerobic metabolism.

- When a person stops exercising, oxygen debt is about 11.5 L of oxygen.

- In addition to 2 L, more O2 (9 L) are needed to reconstitute the phosphagen & glycogen-lactic acid systems.



مهم

Oxygen debt is only with **aerobic** system

توضيح:

أثناء النشاط البدني , ال 2 لتر أوكسجين راح تستخدم , بالإضافة لل phosphagen& Glycogen , وعشان يرجعهم الجسم لحالتهم الطبيعية , راح يحتاج ل 11 L من الأكسجين .

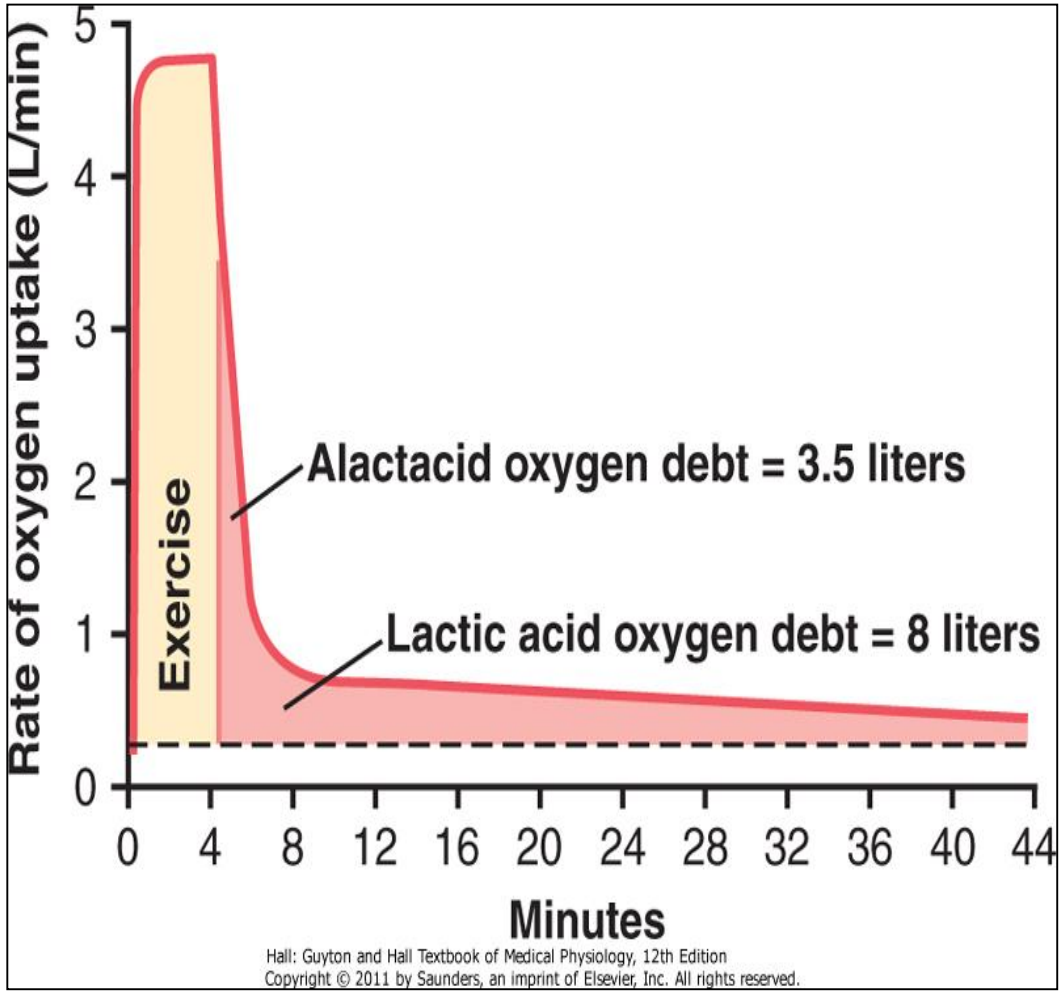
Oxygen Debt

- During the first 4 minutes, O2 uptake is high & fast to refill stored O2 & phosphagen system.
  It is called (alactacid O2 debt = 3.5 L)

- After the first 4 minutes, O2 debt takes 40 minutes for lactic acid removal. Breathing level will be slower.

  It is called (lactic acid O2 debt =8 L)

توضيح:
في اول 4 دقايق بعد النشاط البدني , راح يكون معدل التنفس سريع لتعويض الأوكسجين و phosphagen system, بعدها راح ياخذ الجسم 40 دقيقة عشان lactic acid removal



Recovery of Muscle Glycogen

- Reduction of glycogen stores by heavy exercise needs days to be replenished.
- On high CHO (Carbohydrates) diet, recovery occurs in 2 days.
- On high fat, high protein or on no food all show very little recovery.
- Therefore, athletes should:

1. Have high CHO diet before exercise for ideal recovery. (to have glycogen storage)
2. Not to participate in exhausting exercise during 48 hours preceding the event.

Nutrients Used During Muscle Activity

- During early stages of exercise body use CHO of muscle and liver glycogen.
- Also in intense muscle activity the body uses fats as F.A & very little amino acids.

- 1. If endurance athletic events last longer than 4-5 hours & 2. During exhaustion. Then muscle glycogen is depleted (because it finishes after 1 minute) & muscle depend on fats.

- Glucose solution given to athletes to drink during athletic event supplies 30-40% of energy required during prolonged events such as a marathon race.

Effects of Smoking on Pulmonary Ventilation in Exercise

- Smoking (Nicotine) causes irritation to the bronchioles:

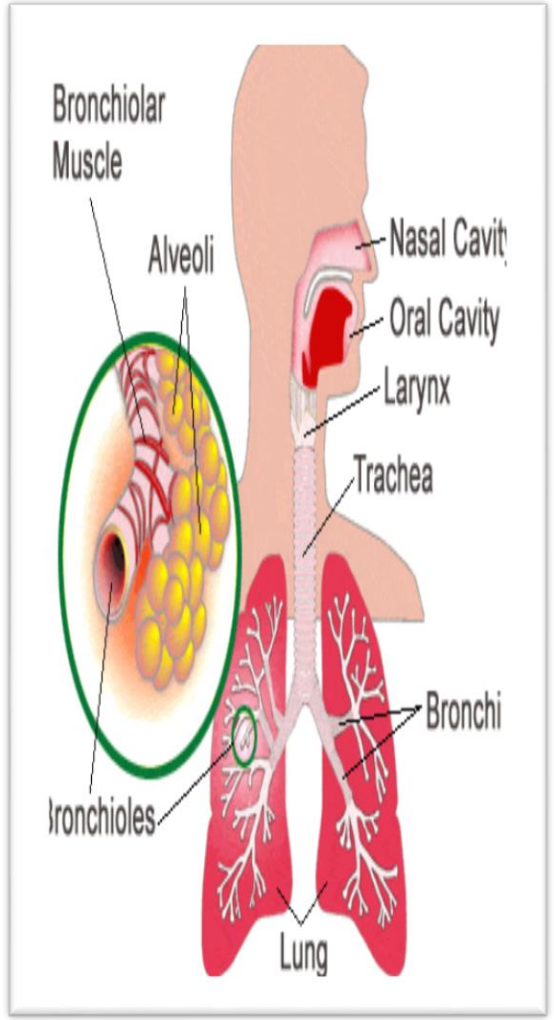
1. By increasing fluid secretion into the bronchial tree and swelling of epithelial layer. Which will constrict the terminal bronchioles and therefore increases resistance of airflow into and out of the lungs.
2. Also , Nicotine paralyzes the cilia of the respiratory epithelial cell surface.

- All lead to fluid and waste accumulation and reduced level of performance.

- Chronic smokers may develop emphysema =

(obstruction of bronchioles + chronic bronchitis + destruction of alveoli)

- so slight exercise causes respiratory distress (pain).



Effects of Heart Disease and Old Age on Athletic Performance

- Cardiac diseases that reduce cardiac output (C.O.P) will reduce muscle power.
- Patient with congestive heart failure has little muscle power to even walk on the floor.

•Recall muscle power : is the amount of work that the muscle perform in a period of time (kg-m/min) .

•N.B the muscle power is inverse proportional with the time.

1. There is 50% decrease in C.O.P between age 18-80 years.
2. There is a decrease in maximal breathing capacity
3. Decrease in muscle mass.

Therefore there is decrease in muscle power with age.

Effect of Body Fluids and Salts in Exercise

- Exercising for 1 hour during endurance athletic events causes 5-10 pounds of weight loss in hot humid atmosphere due to sweat loss.
- Recall: muscle endurance: is the ability of muscles to sustain repeated contractions against a resistance for a period of time.
- Loss of enough sweat reduces performance -5-10% may lead to cramps, nausea & serious effects, so this water lost due to sweat should be replaced.

❑ Sodium tablets or supplemental fluids which contain potassium in the form of fruit juice are required for athletes.

❑ Also Acclimatization to exercise by gradual increase over 1-2 weeks instead of maximal exposure is needed.

-Acclimatization: is the process in which an individual organism adjusts to a gradual change in its environment, to maintain performance across a range of environmental conditions. (التاقلم)

Drugs and Athletes

- Caffeine increases athletes' performance.

Male sex hormone (Androgens) & other anabolic steroids:

1. Increases athletes' performance
2. Increasea the risk of heart attacks due to hypertension,
3. Increase LDL (low-density lipoprotein cholesterol) increasing LDL increase the risk of CVD
4. and decrease HDL. (high-density lipoprotein cholesterol)
   N.B: LDL also called ("bad" cholesterol) , HDL also called ("good" cholesterol)
5. Decrease testicular functions
6. Decrease natural testosterone secretion in males

When women use **Androgens , They develop:**

1. Develop facial hair,
2. Stoppage of menses "menstruation"
3. **Ruddy** "reddish" skin and **bass** "the lowest adult male singing voice." voice

Amphetamine & cocaine improve performance
-BUT **overuse** reduces performance, they are **psychic stimuli.**
***Have a** "psychological effect"

-The action of these drugs in addition to **epinephrine** and **norepinephrine** (hormones of **adrenal medulla**) secreted during exercise lead to **death by ventricular fibrillation**.

epinephrene A hormone secreted by the adrenal medulla that is released into the bloodstream in response to physical or mental stress,

Body Fitness Prolongs Life

- Studies show that body fitness, exercise & weight control prolong life (between 50-70 yrs)

- Reasons:-

  1- Reduce CVD (cardiovascular diseases), heart attacks, brain stroke and kidney disease due to low blood pressure, low blood cholesterol, low LDL, and high HDL.

  2- Reduces insulin resistance and type 2 diabetes.

  3- Reduces the risk of breast, prostate, and colon cancers and reduces obesity.

Quiz

- https://www.onlineexambuilder.com/physical-and-psycological-factors-affecting-sport-performance/exam-120808

Link to Editing File

(Please be sure to check this file frequently for any edits or updates on all of our lectures.)

References:

- Girls' and boys' slides.
- Guyton and Hall Textbook of Medical Physiology (Thirteenth Edition.)

Thank you!

اعمل لترسم بسمة، اعمل لتمسح دمعة، اعمل و أنت تعلم أن الله لا يضيع أجر من أحسن عملا.

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