Editing File

Physical & Physiological Factors in Athletic Performance

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Ty to Hasan Alsugahyir for sketch (MED445 inshallah) <3

Objectives

01

Identify the muscle metabolic systems and the nutrients used in exercise to regenerate ATP.

i. Phosphocreatine-creatine system,

ii. Glycogen-lactic acid system,

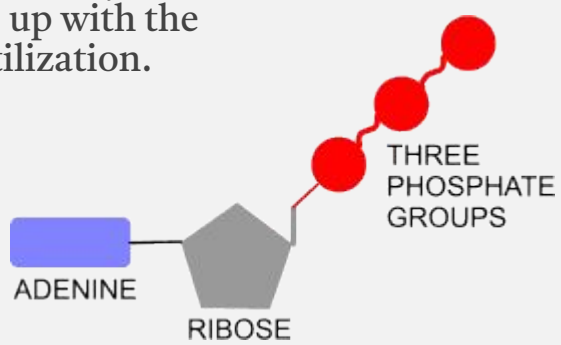
iii. Aerobic system.

02

Explain the recovery of glycogen and the muscle metabolic systems after exercise.

Metabolic pathways in skeletal muscle

- Adenosine triphosphate (ATP) is the only energy source used directly by the muscles for contractile activities
- At rest: muscle cell contains a small store of ATP, but it cannot rely on this ATP once it begins contracting.
- The **demand** and the **mechanism** of ATP production vary according to the type of work done.
- Muscle cell must get ready for ATP production to keep up with the increased rate of utilization.



Energy for Muscle Contraction

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

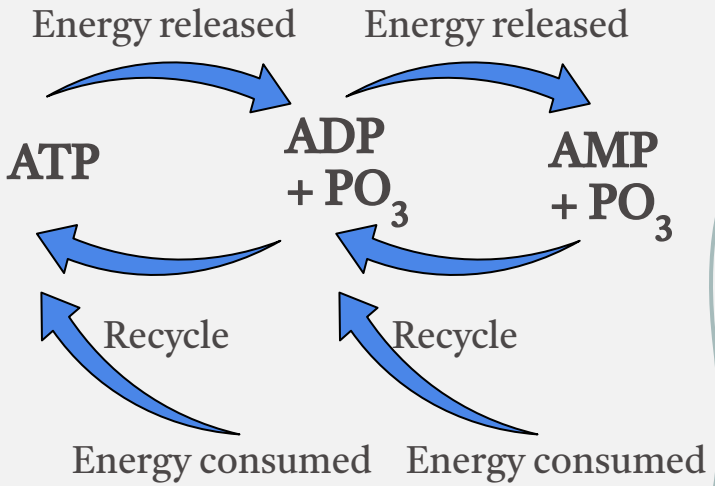
➔ Adenosine-PO_3 ~ PO_3 ~ PO_3

- Each of the last 2 high energy phosphate bonds in ATP stores 12,000 calories per mole of ATP.

- All ATP stored in the muscle is sufficient for only 1- 2 seconds of muscle power.

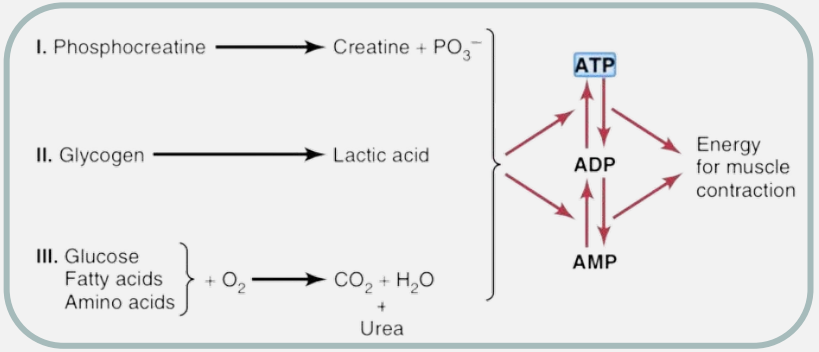
➔ Enough for half of a 50-meter dash (25m)

- Resting muscles must have energy stored in **other forms** (Creatine Phosphate (CP) - glycogen-etc.) to convert ADP into ATP.



ATP regeneration

- As we begin to exercise, we almost immediately use our stored ATP within few seconds and it will changed into ADP.
- ATP is regenerated from ADP by 3 pathways:



Muscle Metabolic Systems in Exercise

- 1-Direct phosphorylation of ADP by creatine phosphate (CP)
  - Immediate
  - Exercise for seconds
- 2-Anaerobic pathway Of Glycolysis (glycogen → lactic acid)
  - Short-term
  - 60-90 seconds of exercise
- 3-Aerobic oxidation of nutrients (fatty acids, amino acids and pyruvic acid) in the mitochondria
  - Long-term
  - 1 hour or more of exercise

Interaction of the energy systems

Immediate

First few seconds.

Short-term

Long-term

Aerobic. Till the end of the exercise.

Notice that the systems can be integrated.

1-Phosphocreatine-creatine system (creatine ~ Po3) (CP) (Direct phosphorylation pathway)

- CP: contain high energy phosphate bond of 13,000 calories/mole.

-Most muscle cells have 3 - 8 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.

Phosphocreatine + ADP
(the muscle is relaxed)

↕

ATP + Creatine
(energy for muscle contraction)

-Phosphagen Energy System

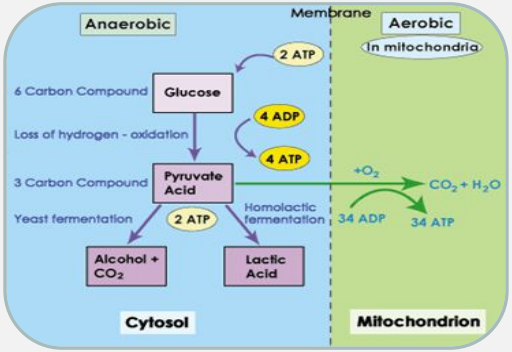
- **Phosphagen energy system:** combined amounts of cell ATP + cell phospho-creatine.
  - These <u>together</u> provide maximal muscle power for 5 to 10 seconds (enough for 100-meter run).
  - Energy of phosphagen system is useful for maximal short bursts of muscle power.

2) Anaerobic Glycolysis (Glycogen-Lactic Acid System)

- **Anaerobic glycolysis**: the primary energy source for peak (severe) muscular activity.

- **Provides** 1.3 - 1.6 minutes of maximal muscle activity.

-**Produces** 2 ATP molecules per molecule of glucose coming from blood.



Glycolysis: (in the muscle)

Glycogen → **Glucose** → **Pyruvic acid (x2)** → **Lactic acid (x2)** → Diffuses out of muscles. → **Blood** → **liver**

Pyruvic acid (x2) → **2 ATP 2 NADH**

Lactic acid (x2) → **2 NAD+**

Gluconeogenesis: (in the liver)

2 Lactic acid (x2) → **Pyruvic Acid (x2)** → Needs ATP → **Glucose** → **Blood** → **Taken by the muscle Again**

Which type of sports uses anaerobic metabolism?

Sports that require bursts of speed & activity, that requires up to 1.3-1.6 minutes
e.g.

- 400-meter dash
- 100-meter swim
- Tennis
- Soccer

Why anaerobic metabolism is inefficient?

- Large amounts of glucose are used for very small ATP returns
- Lactic acid is produced whose presence contributes to muscle fatigue

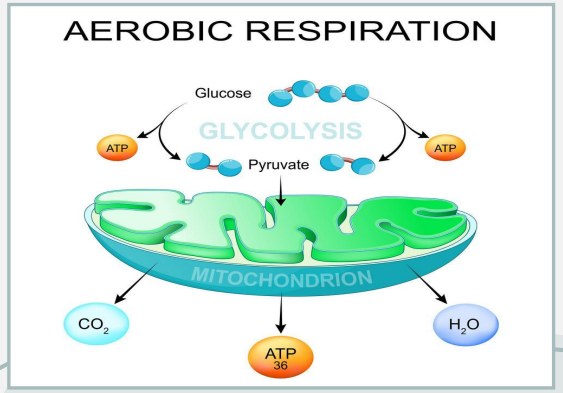
3) Aerobic System/Metabolism

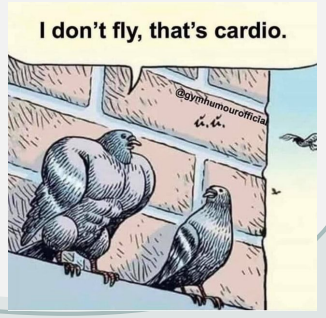
Aerobic metabolism: the primary energy source of resting muscles to convert glucose into glycogen and to create energy storage compounds as CP.

-During rest and light to moderate exercise: aerobic metabolism contributes 95% of the necessary ATP.

-Breaks down **fatty acids**, **pyruvic acid** (made via glycolysis), and **amino acids**.

-Produces maximum 36 ATP molecules per glucose molecule.





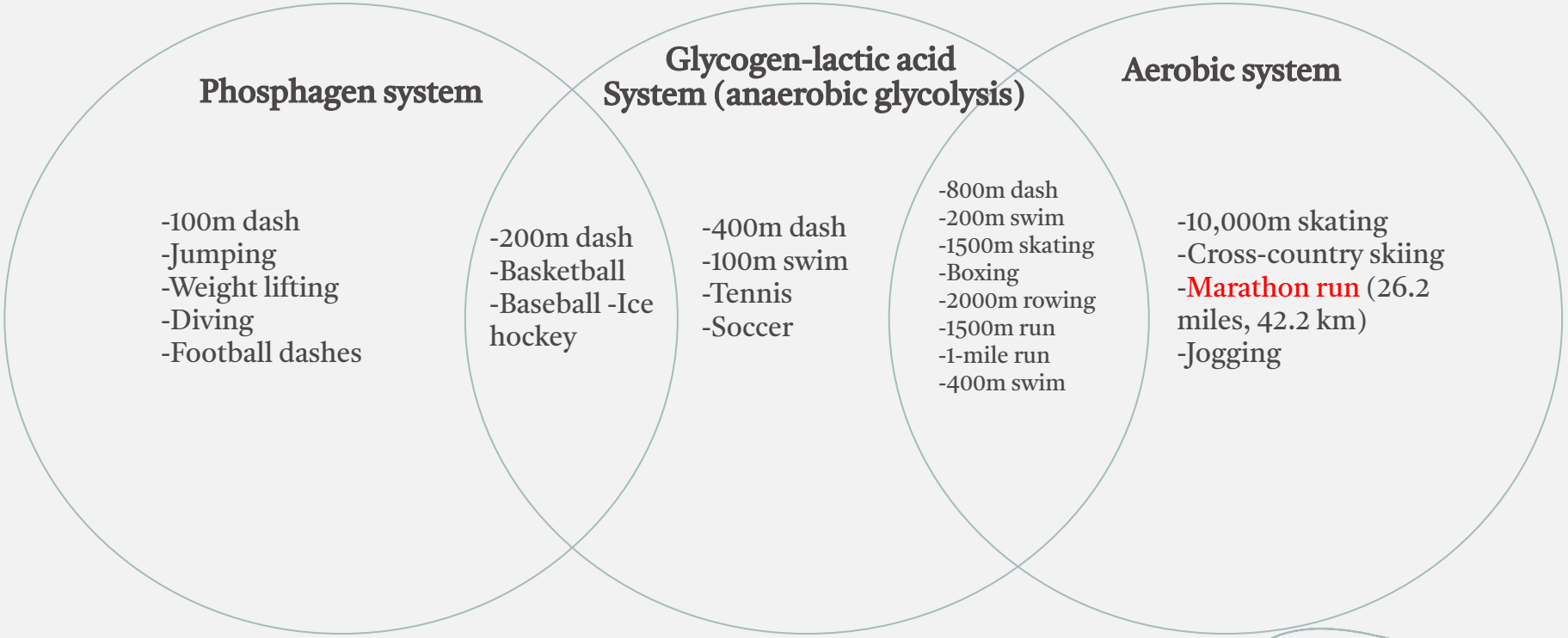
Comparing the Energy Supply of the 3 Systems:

(Phosphagen - Anaerobic - Aerobic)

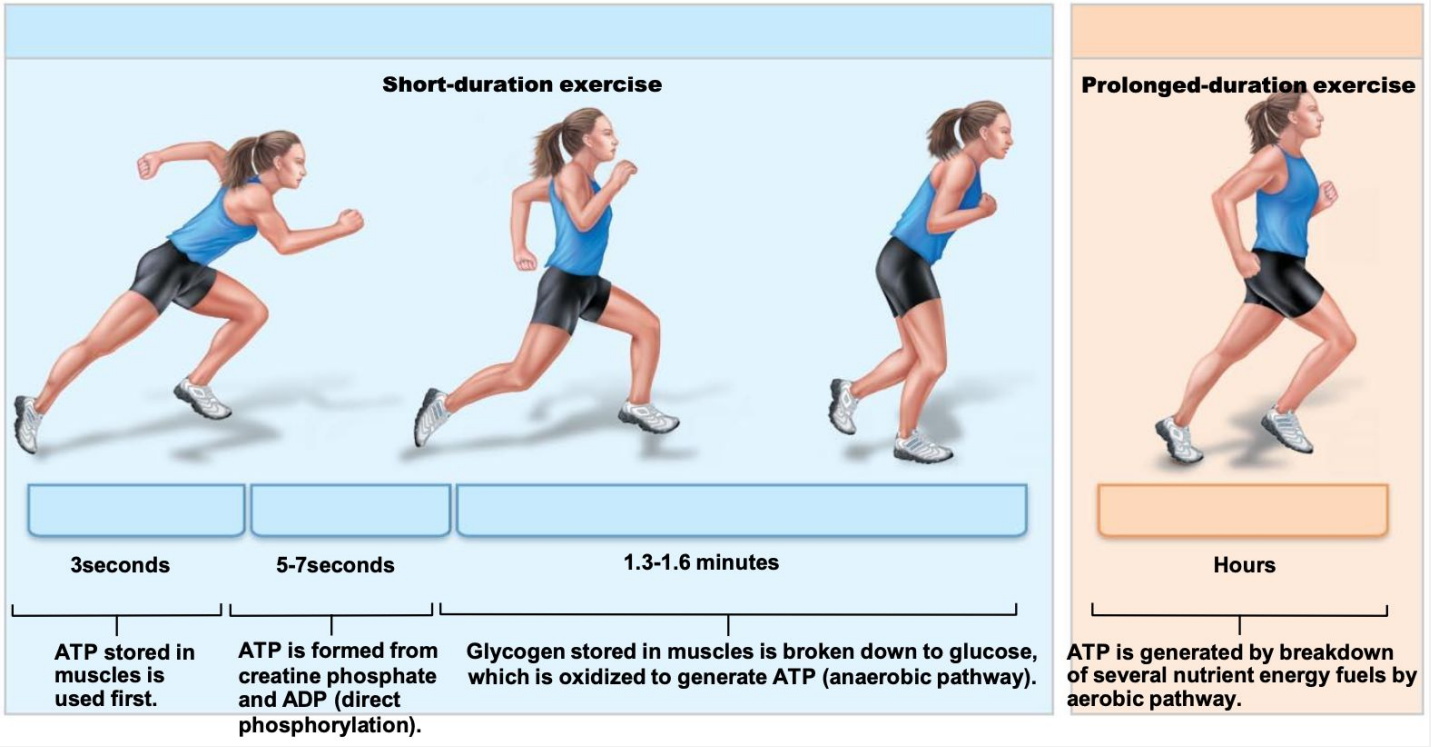
Systems	`ATP Generation (moles of ATP/min)	Time (endurance)
Phosphagen CP + ATP	4	8 - 10 sec(تمارين قصيرة)
Anaerobic Glycogen-lactic acid system	2.5	1.3 - 1.6 min
Aerobic	1	unlimited (as long as nutrients last)

Energy systems used in various sports

(Phosphagen - Anaerobic - Aerobic)



Comparison of energy sources used during short-duration exercise and prolonged-duration exercise.



Nutrients Used During Muscle Activity

- **Early stages of exercise:**
  body uses glycogen of muscle and liver.

- **Intense muscle activity:**
  body uses fat + very little amount of amino acids.

- **Endurance athletic lasts longer than 4-5 hours + during exhaustion:** muscle glycogen is depleted (يخلص الجلايكوجين) + muscle depend on fat.

- Glucose solution is given to athletes to drink during athletic events supply 30 - 40% of the energy required during prolonged events as marathon race.

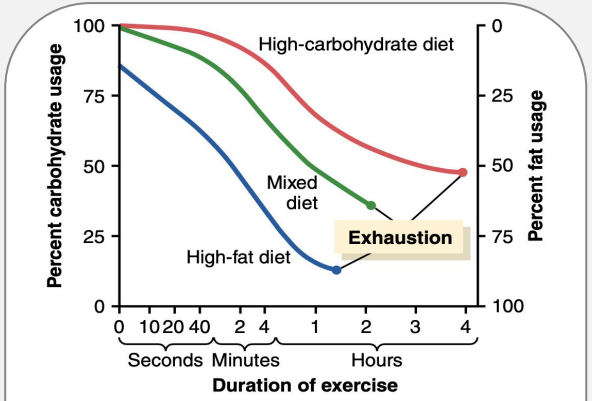


Figure 84-4 Effect of duration of exercise, as well as type of diet on relative percentages of carbohydrate or fat used for energy by muscles. (Based partly on data in Fox EL: Sports Physiology Philadelphia: Saunders College Publishing, 1979.)

Recovery of muscle glycogen

- Reduction of glycogen stores by heavy exercise needs days to be replenished (unlike ATP, CP, and removal of lactic acid which takes shorter periods).
- On high CHO (carbohydrates) diet → recovery occurs in 2 days.
- On high fat, high protein or no food at all diet → very little recovery even after as long as 5 days.
- Athlete should have high CHO diet before exercise.
- Athletes should avoid participating in exhausting exercise during the 48 hours preceding (before) the event.

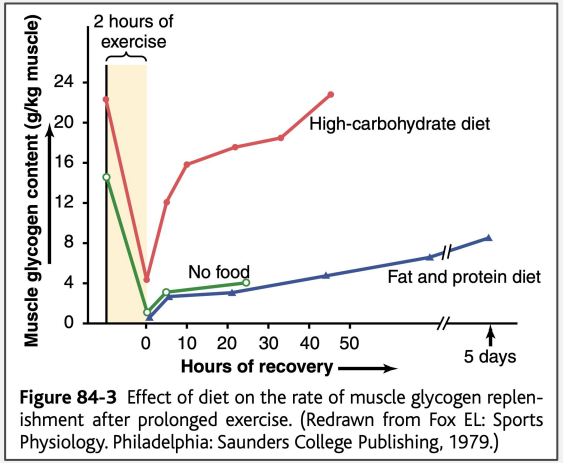
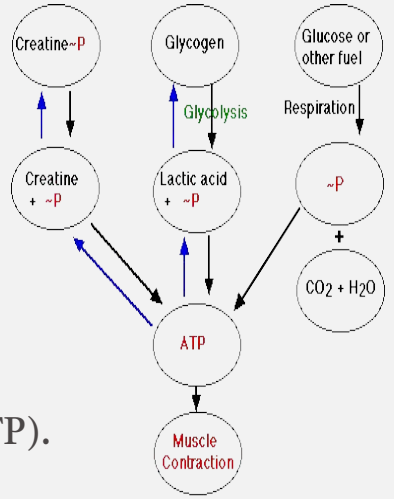


Figure 84-3 Effect of diet on the rate of muscle glycogen replenishment after prolonged exercise. (Redrawn from Fox EL: Sports Physiology. Philadelphia: Saunders College Publishing, 1979.)

Recovery of Muscle Metabolic Systems After Exercise



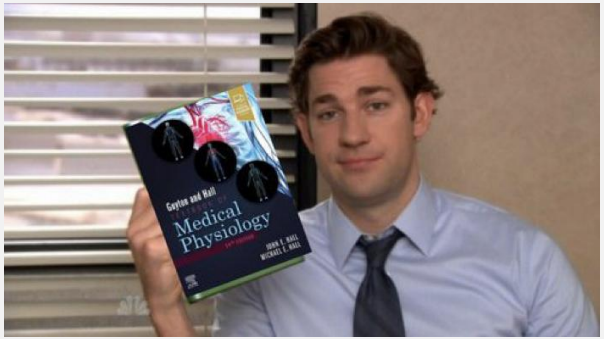
- Energy from CP reconstitute (restore) ATP.
- Energy from glycogen-lactic acid system reconstitute the phosphagen system (CP + ATP).
- Energy from oxidative metabolism of aerobic system reconstitute all other systems: glycogen - lactic acid system + CP + ATP.
- Lactic acid causes fatigue and burning sensation in muscles, so when adequate amounts of energy are available from oxidative metabolism, the lactic acid will be removed in two ways:

1) Portion converted into pyruvic acid that is oxidized by all body tissues.

2) Major remaining part is changed into glucose in the liver to replenish glycogen stores of muscles.

You can find the pages related to this lecture from (Guyton) here

Note: Guyton has extra information that might not be with us, but if you want to learn more about the topic make sure to check it out :3



Thanks to team 443 <3

MCQs

1-D 2-A

Q1: Which system is used in weight lifting?			
A- Aerobic system	B- Anaerobic system	C- Glycogen-Lactic acid system	D- Phosphagen energy system
Q2: Marathon runners depend on which source of energy?			
A- Glucose	B- Photosynthesis	C- Amino acids	D- Glycogen

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