Physical and Psychological Factors Affecting Sport Performance

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Objectives

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

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

   Phosphocreatine-creatine system,

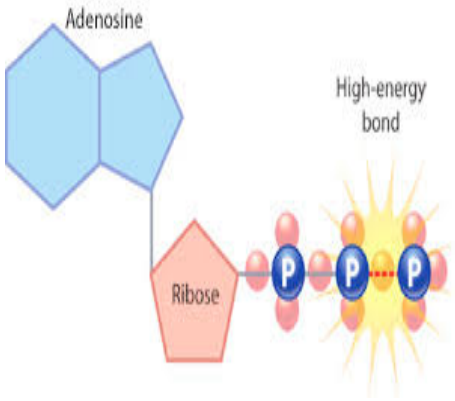
   Glycogen-lactic acid system,

   Aerobic system.

2. 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.



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.
- Muscle cell must get ready to ATP production to keep pace with the increased rate of utilization.

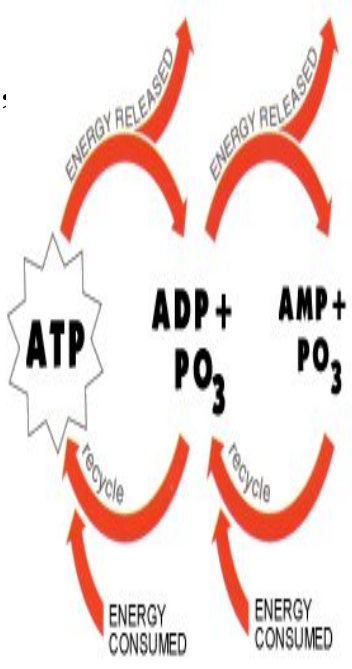
Energy for Muscle Contraction

- Mitochondria in the muscle converts glucose, fatty acids, and amino acids into ATP (Adenosine-PO3 ~ PO3 ~ PO3).

- 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).

- So resting muscles must have energy stored in

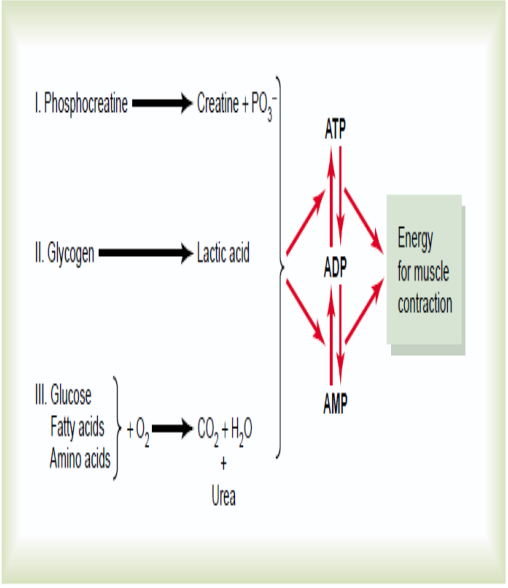


ATP regeneration

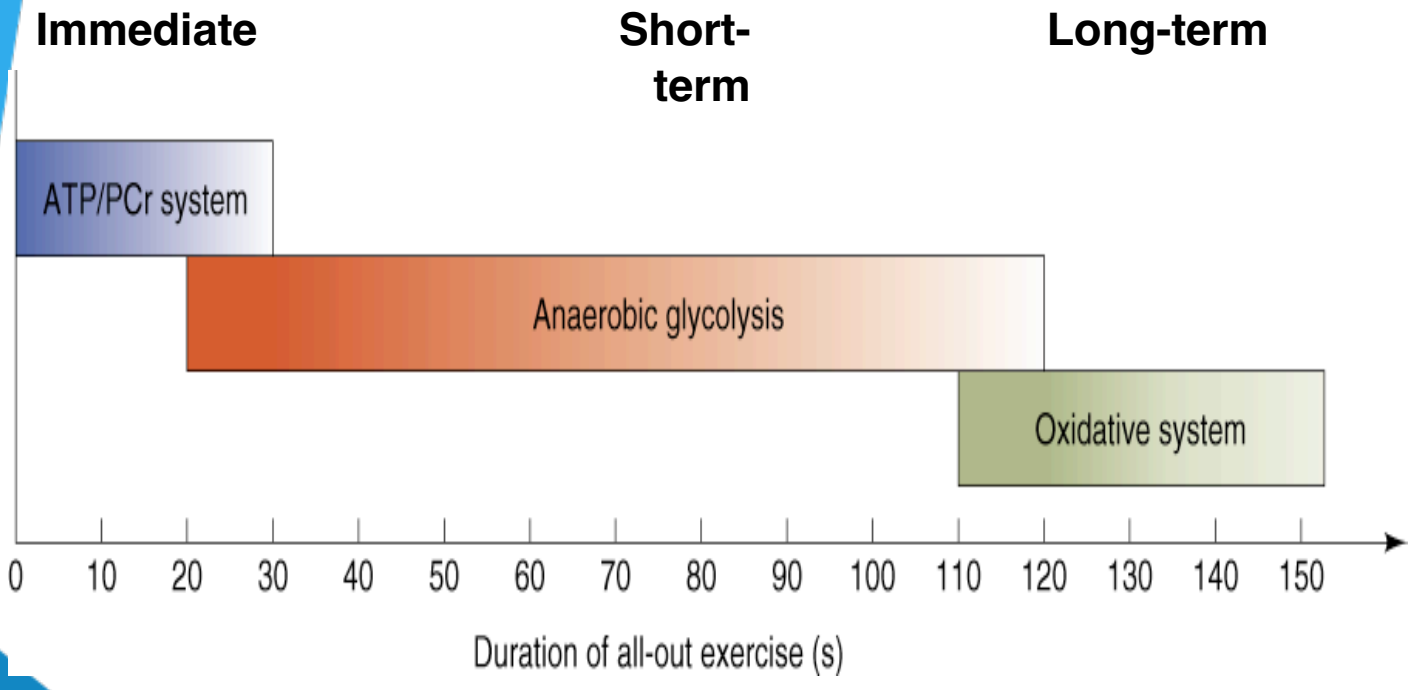
- As we begin to exercise, we almost immediately use our stored ATP within few seconds and it will changed into ADP.

ATP is regenerated from ADP by 3 pathways:

1-Direct phosphorylation of ADP by **creatine phosphate** (CP).
2-Anaerobic pathway (glycolysis lactic acid).
3-Aerobic oxidation of fatty acids in the mitochondria

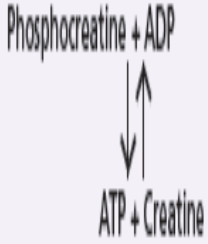


INTERACTION OF ENERGY SYSTEMS



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

- CP: Contain high energy phosphate bond o 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.



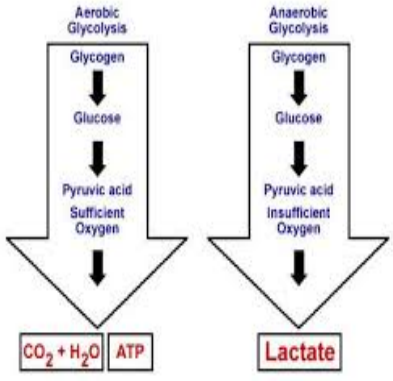
Phosphagen energy system:

Formed of combined amounts of cell **ATP + CP**

- Together provide maximal muscle power for 5-10 seconds (enough for 100 meter run).
- Energy of phosphagen system is useful for **maximal short bursts of muscle power (5-10 seconds)**. E.g
- Jumping
- Diving
- Weight lifting

II- Anaerobic Glycolysis (Glycogen-Lactic acid system)

Is the primary energy source for peak (sever) muscular activity.
It provides 1.3-1.6 minutes of maximal muscle activity.

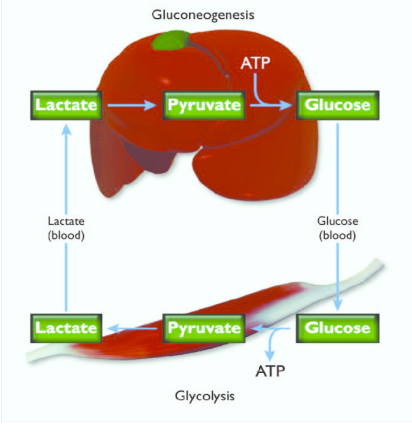


Produces **2 ATP** molecules per molecule of glucose coming from blood.

Glucose □ 2 pyruvic acid + 2 ATP

2 Pyruvic acid □ 2 **lactic acid**

Lactic acid diffuses out of muscles □blood □ taken by the liver □ Glucose (by gluconeogenesis) □blood □ taken by the muscle again.



Anaerobic metabolism is inefficient… Why?

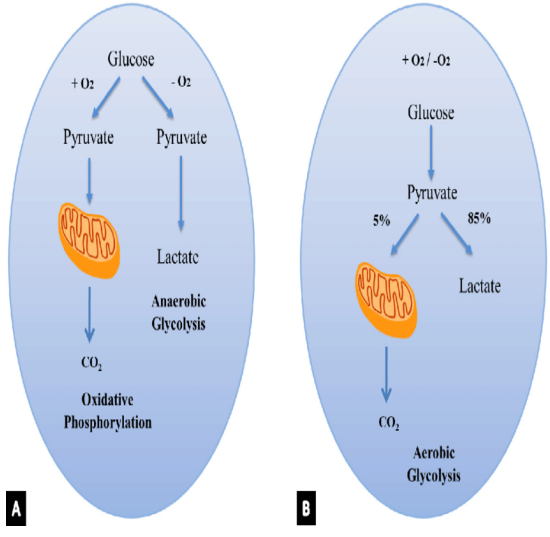
- Large amounts of glucose are used for very small ATP returns.
- Lactic acid is produced whose presence contributes to muscle fatigue.

Which type of sports uses anaerobic metabolism?

- Sports that requires bursts of speed and activity, that requires up to 1.3-1.6 minutes e.g
- 400-meter dash
- 100-meter swim
- Tennis
- Soccer

Aerobic Metabolism

- Is 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.
- It breaks down **fatty acids**, **pyruvic acid** (made via glycolysis), and **amino acids**.
- Produces maximum 38 ATP molecules per glucose molecule.



Comparing the Energy Supply of the Phosphagen System, Anaerobic and the 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

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)

Figure 9.20 Comparison of energy sources used during short-duration exercise and prolonged-duration exercise.

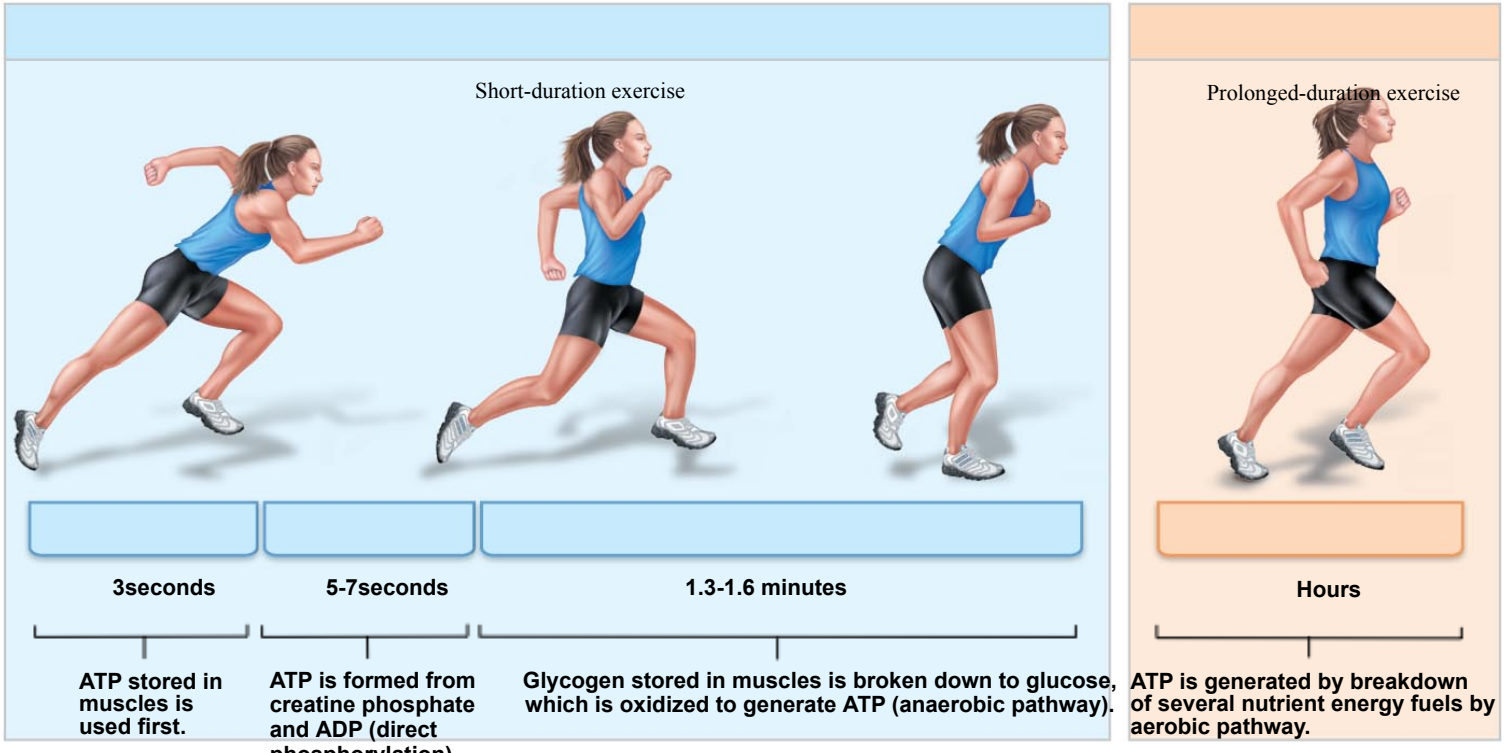


Table 84–1

Energy Systems Used in Various Sports

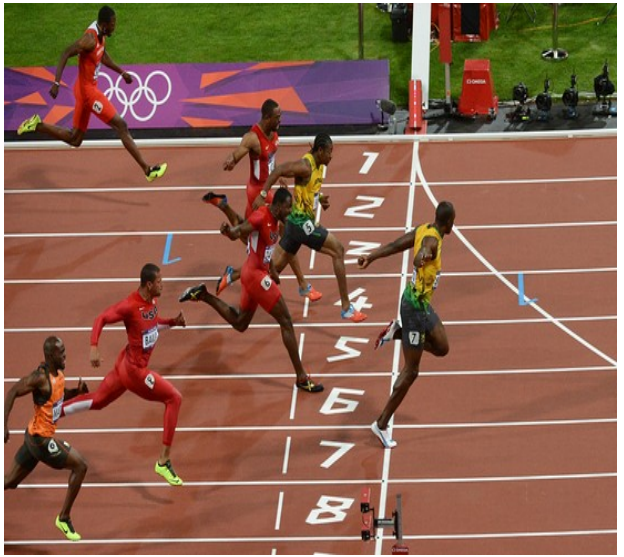
Phosphagen system, almost entirely
- 100-meter dash
- Jumping
- Weight lifting
- Diving
- Football dashes

Phosphagen and glycogen-lactic acid systems
- 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
- 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



Nutrients used during muscle activity

- During early stages of exercise the body uses glycogen of muscle and liver. Also in intense muscle activity the body uses fats and very little amino acids.

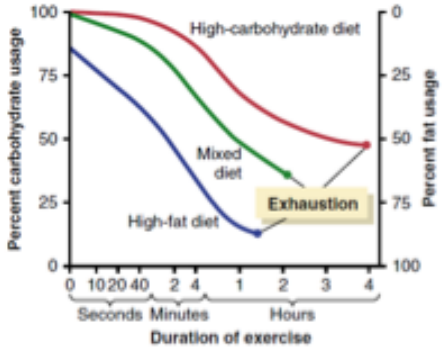


Figure 85-5 The effect of duration of exercise, as well as type of diet, on relative percentages of carbohydrate or fat used for energy by muscles. *(Data from Fox EL: Sports Physiology. Philadelphia: Saunders College Publishing, 1979.)*

- If endurance athletic events last longer than 4-5 hours & during exhaustion muscle glycogen is depleted & muscle depend on fats.

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

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 carbohydrate (CHO) diet, recovery occurs in 2 days.

-On high fat, high protein or on no food all show very little recovery even after 5 days.

<u>Message:</u>

1- Athlete should have high CHO diet before exercise.

2- Not to participate in exhausting exercise during 48 hours preceding the event.

Read <u>Guyton & Hall: Textbook of Medical Physiology 14 th E</u>

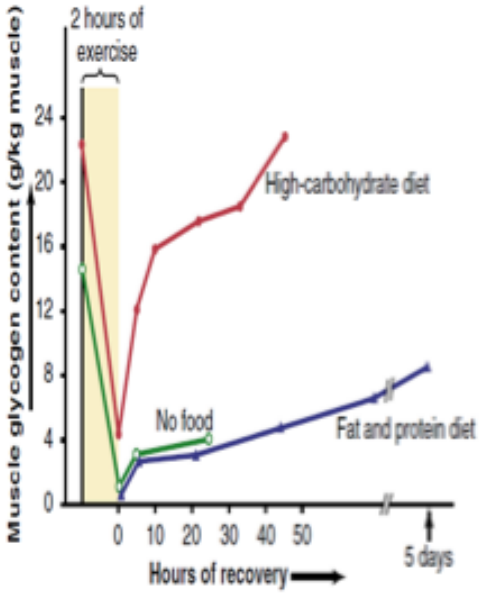


Figure 85-4 The effect of diet on the rate of muscle glycogen replenishment after prolonged exercise. *(Modified from Fox EL: Sports Physiology. Philadelphia: Saunders College Publishing, 1979.)*

Recovery of muscle metabolic systems after exercise

- Energy from CP reconstitute 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 the muscles so it should be removed:

When adequate amounts of energy are available from oxidative metabolism, removal of lactic acid is achieved in two ways:

1-Portion converted into pyruvic acid that is oxidized by all body tissues for energy .

2-The major remaining part is changed into glucose in the liver to replenish glycogen stores of muscles.

Thank you