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Physical and Physiological Factors Affecting athletic Performance

- Very important
- Extra information
- Terms

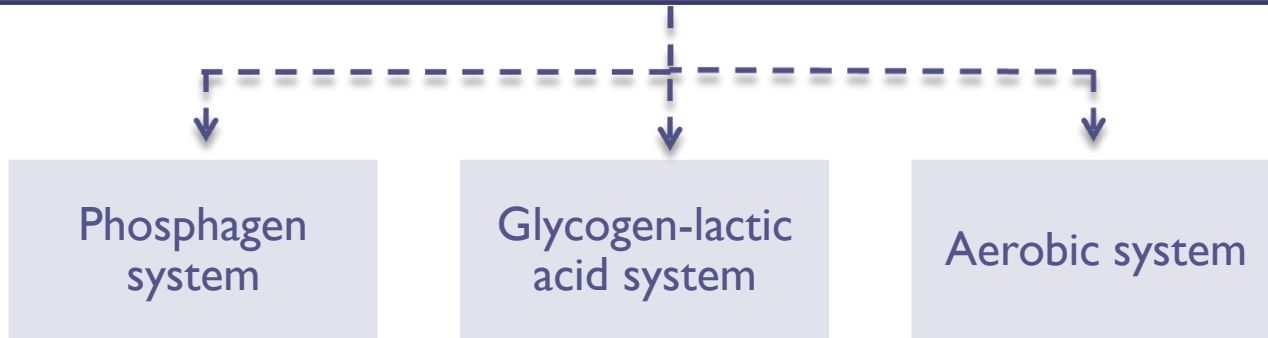
Take care of your body, it is the only place that you have to live in !



- Know the 3 metabolic systems exceedingly important in understanding the limits of physical activity.
- know recovery of the aerobic system after exercise and O₂ dept.
- Understand the Effects of smoking on pulmonary ventilation in exercise & effect of heart disease.
- Know effect of some drugs on athletes performance.
- Know the causes and effect of fatigue on sport performance.
- Identify overtraining syndrome.

Metabolic system

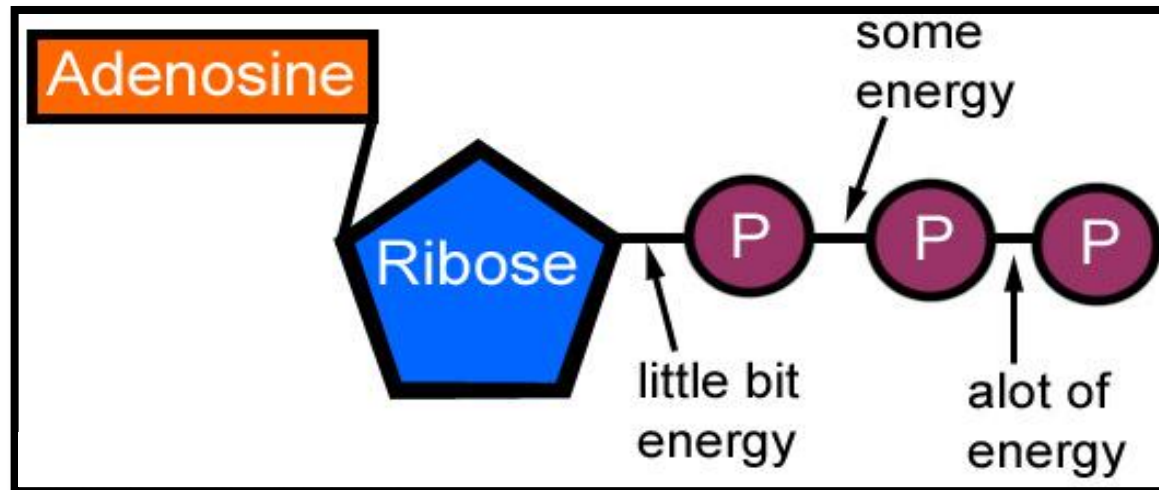
There are 3 metabolic system exceedingly important in understanding the limit of physical activity :



Adenosine triphosphate (ATP)



Each one of the **last 2 high energy phosphate bonds** store **7300 calories** which are used to energize the muscle contractile process



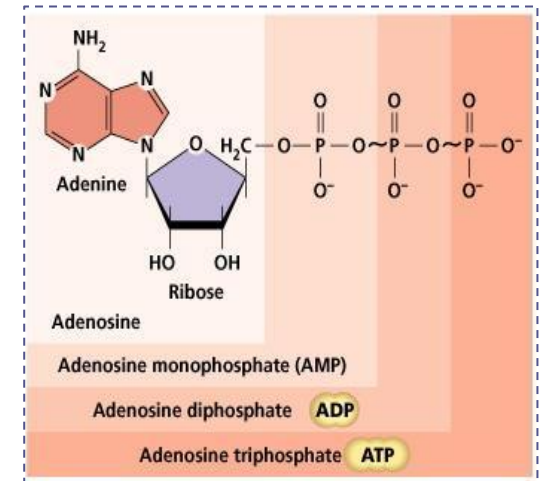
ATP structure

Adenosine triphosphate (ATP)

Removal of one bond converts ATP to ADP then removal of one more forms AMP

All ATP in muscle is sufficient for only 3 seconds of muscle power
(enough for one half of a 50 meter dash)

It is essential to form new ATP continuously even during performance of short athletic events.



للتوضيح :
تخيل نفسك انت adenosine
و الحصن الأول للدفاع عنك هو الأم فلازم تكون قريبة منك زي ما وصانا الرسول بالبر بالأم ثلاث مرات ولذلك
(mom = AMP)
و الحصن الثاني هو الأب وهو الوصاية الثانية لذلك
(dad=ADP)
و الحين صار عندنا حصانتين أم و أب و هذا يعزز ثقتنا بنفسنا و يخلينا نكتسب حصانه ثلاثة وهنا بتكون عندنا طاقة
(trust = ATP)

Phosphocreatine – creatine system

Phosphocreatine – creatine system = creatine-phosphate system (creatine PO_3) :

- Contain **high energy** phosphate bond has **10300 calories/mole** , so CP "creatine phosphate" provide enough energy to reconstruct high energy bond of ATP. "Reconstruct إعادة بناء"
- Muscle cell have **2-4 times** as much CP as ATP.
- Energy transfer from CP to ATP occurs within a small fraction of second. Therefore , energy of muscle CP is available for contraction just as **stored energy of ATP**.

- **Phosphocreatine-creatine** : يعطينا الطاقة اللازمة لتكوين الـ ATP
- Most muscle cells have 2-4 times as much CP as ATP
- يعني الكرياتين فوسفات في العضلات أكثر بمرتين إلى أربع مرات من ATP لأنها هي اللي تنتج فطبيعي تكون أكثر منه
- The presence of CP = there is energy for formation of ATP =there is energy for muscle contraction.

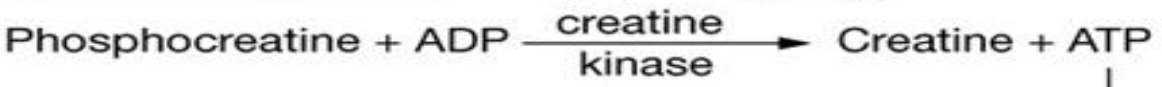
[Video](#)

Phosphocreatine – creatine system “EXTRA”

Muscle at rest



Working muscle



needed for

- Myosin ATPase (contraction)
- Ca²⁺-ATPase (relaxation)
- Na⁺-K⁺ ATPase (restores ions that cross cell membrane during action potential to their original compartments)

[Video](#)

Phosphagen energy system

Phosphagen energy system :

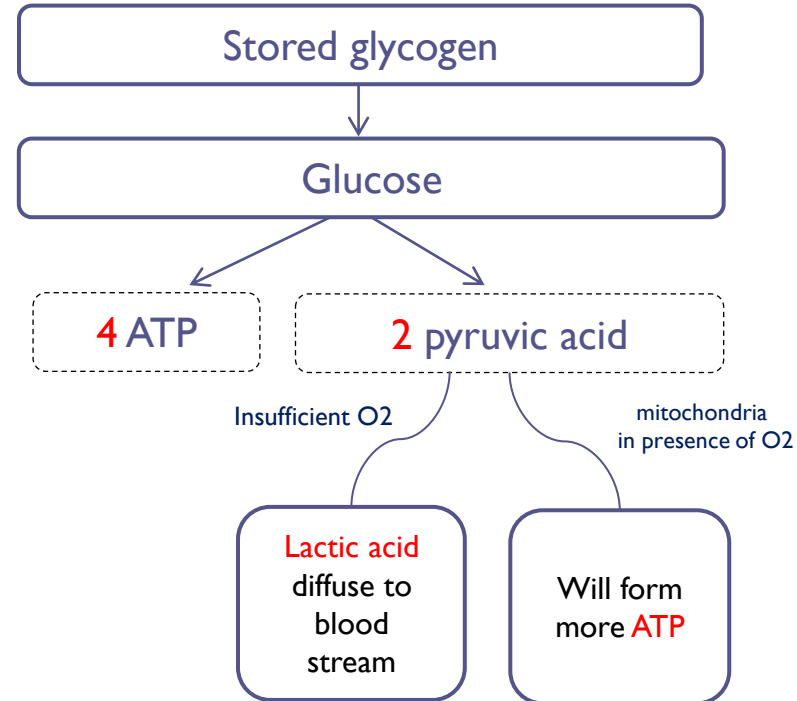
- It is formed of [**combined amount of cell ATP + CP**] together provide maximal muscle power for **8-10 seconds** (enough for 100 meter run).
- Energy of phosphagen system is useful for **maximal short bursts** of muscle power.

- Phosphagen energy system = (CP + ATP)
- Notice that :
ATP system > 3 sec. / Phosphagenenergy system > 8-10 sec.
- Phosphagenenergy system : أي حركة قوية وسريعة (أقل من ٨ ثوانٍ)
أما إذا كان أكثر من ٨ ثوانٍ لن يتم استخدام هذا النظام



Anaerobic metabolism (glycolysis):

- During glycolysis : glycogen of the muscle split into glucose (**Glycogenolysis**) **without use of O₂**.
- Then each glucose split into :
2 pyruvic acid + energy to form 4 ATP
[for each **one** glucose molecule]
- Then **pyruvic acid** in the mitochondria **in presence of O₂** will form more ATP (**oxidative stage**).
- When there is insufficient O₂ most of pyruvic acid converts into **lactic acid** which diffuse to blood stream.



- Glycogen-lactic acid system [Anaerobic metabolism(glycolysis)]:
- يكسر الجلايكوجين المخزن في العضلات إلى جلوكوز في غياب الأوكسجين
- Every glucose molecule then splits into : 4 ATP + 2 Pyruvic acid
- الـ Pyruvic acid يتجه إلى الـ Mitochondria عند توفر الأوكسجين فقط : ينتج المزيد من الـ ATP
- إذاً نقدر نقول أن العملية ككل تمت في غياب الأوكسجين ، لكن أحد عناصر هذه العملية وهو الـ Pyruvic acid يدخل في مرحلة تسمى (oxidative stage) بتوفر فيها الأوكسجين ليعطينا المزيد من الطاقة
- في حال عدم توفر الأوكسجين للـ Pyruvic acid سيتحول إلى حمض اللاكتيك ويسبب شد عضلي

[Video](#)

- Glycogen-lactic acid system can form ATP molecules (Anaerobically) 2.5 times as rapidly as can oxidative mechanism of mitochondria.
- Anaerobic Glycolysis can provide large ATP amounts needed for short - moderate periods of muscle contraction ($\frac{1}{2}$ as rapid as phosphagen system) .
- Glycogen-lactic acid system provide 1.3-1.6 minutes of maximal muscle activity (8-10 seconds provided by phosphagen system) .



عند تحرك العضلة واحتياجها للطاقة تبدأ بتكسير سلاسل الجلايكوجين الموجودة في العضلات إلى جلوكوز ومن ثم ينكسر الجلوكوز إلى جزيئين بايروفيت كما درسناها سابقاً ، بوجود الاكسجين ستكمل دورتها إلى أن تنتج ٣٨ جزيء طاقة وفي حالة عدم توفر الاكسجين سننتج جزيئين طاقة + حمض اللاكتيك. يحدث ذلك غالباً عند التحرك المجهد في زمن قصير لأن إنتاج الطاقة بهذه الطريقة لا يتطلب وقتاً طويلاً.

- Lactic acid : in blood stream > fatigue / it can be used to produce ATP.
- Anaerobic Glycolysis can provide large ATP amounts needed for short –moderate periods of muscle contraction ($\frac{1}{2}$ as rapid as phosphagen system) : phosphagen system من الـ (أبطأ) مما يعني أنه يستمر لفترة أطول
- Glycogen-lactic acid system provide : 1.3-1.6 minutes [not enough for 3 minutes exercise]

Aerobic process

Aerobic process :

- Oxidation of foodstuffs (glucose, amino acid , fatty acid) in the mitochondria in **presence of O₂** produces energy that converts **AMP(1)** to **ADP(2)** to **ATP(3)**
- Supply energy for **Unlimited time.**

يسمى هذا النظام بالنظام الهوائي وهو ما يحدث في أجسامنا أغلب الأوقات لإنتاج الطاقة (تحلل الجلوكوز ثم دورة كربس وسلسلة نقل الإلكترونات) رغم أنه أبطأ من النظامين السابقين إلا أنه أهمها وأكثرها إنتاجاً للطاقة وهو ضروري لنشاطات الجسم اليومية.

- Both the anaerobic and aerobic systems are working at the beginning of exercise.
- The anaerobic system is providing most of the energy at first. BUT as the duration of exercise increases the aerobic system kicks in and becomes the main supplier of energy to our body.

[Video](#)



Contact us : Physiology435@gmail.com


Differences between 3 systems

- All the process as a whole will give us :

System	Moles of ATP/min	Endurance time
Phosphagen system	4 moles	8 – 10 seconds
Glycogen-lactic acid system	2.5 moles	1.3 – 1.6 minutes
Aerobic system	1 mole	Unlimited time as long as nutrients last

Extra


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



Phosphagen system

8-10 seconds (100 m)


Sprinter



Glycogen-lactic acid system

1.3-1.6 minutes (400 m)

Swimmer



Aerobic respiration

Unlimited time (15 Km)

Marathon runner

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Recovery of muscle metabolism system after exercise

1

Energy from **CP** reconstitute **ATP**

2

Energy from **glycogen-lactic acid system** reconstitute **phosphagen system** (CP+ATP)

3

Energy from **oxidative metabolism** of aerobic system(food) reconstitute all other system
[glycogen-lactic acid system + phosphagen system (CP+ATP)]

4

Lactic acid system reconstitution means Removal, how ?



Next slide :)

بعد الانقباض العضلة استهلكت كل كمية الطاقة الموجودة فيها، كيف تراج العضلة لوضعها الطبيعي وترجع الطاقة التي استهلكت أثناء الانقباض ؟ عن طريق النقاط المذكورة أعلاه.



Recovery of muscle metabolism system after exercise

Lactic acid cause fatigue

if it accumulates in the muscle so it is removed in 2 ways :

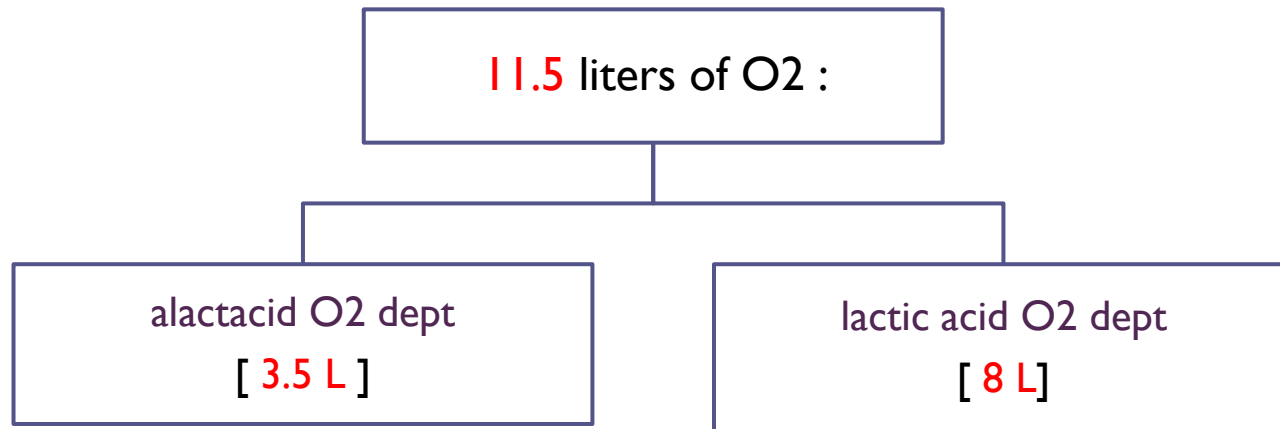
One portion converted into **pyruvic acid** and oxidated by tissues
“and give energy”

remaining is changed into **glucose** in liver
to replenish glycogen stores of muscles

جزء منه يتحول إلى pyruvic acid وجزء يتحول إلى جلوكوز يتجه إلى الكبد : Lactic acid

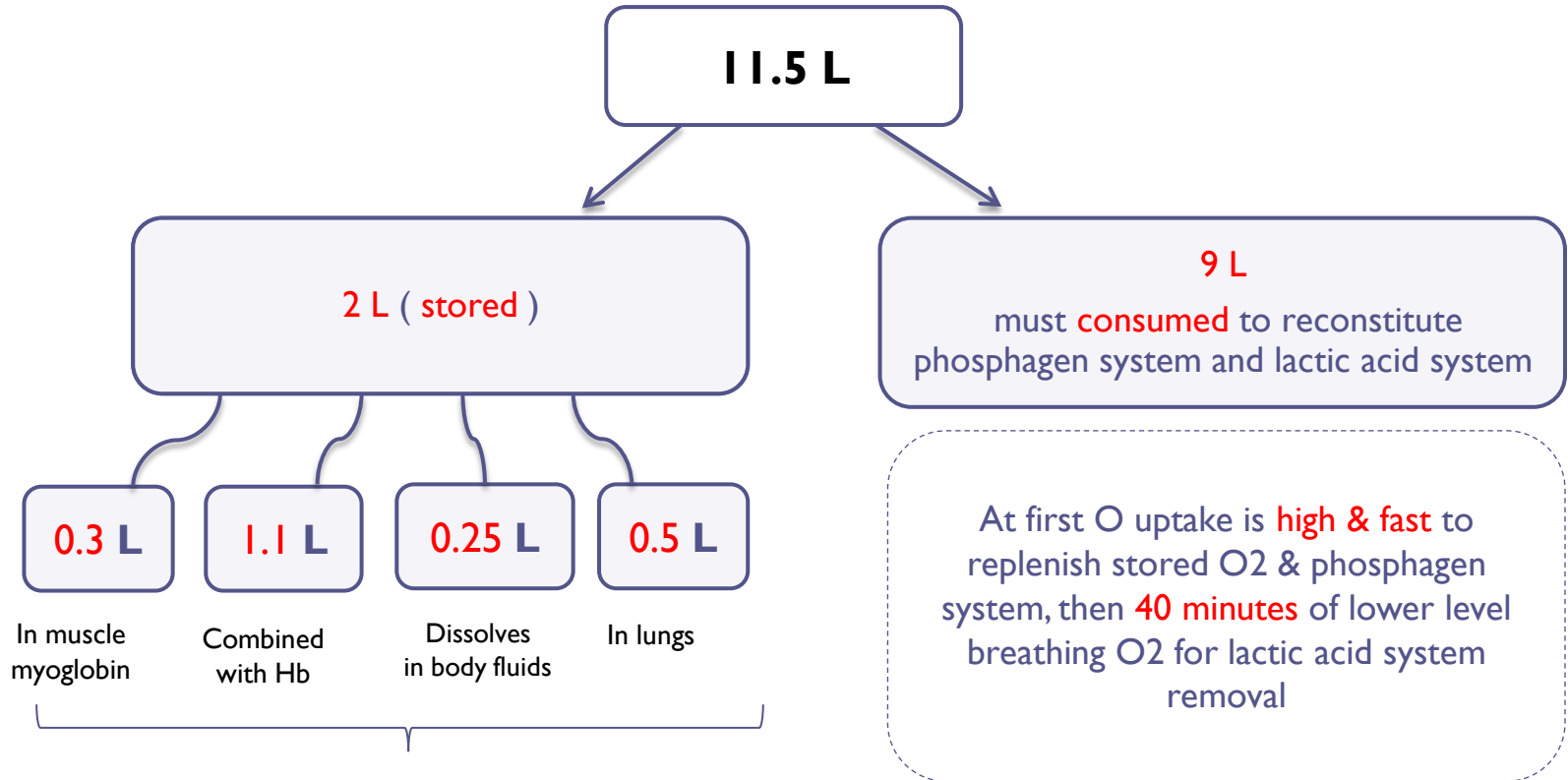
■ Oxygen Debt :

This is **11.5** liters of O₂ should be repaid after exercise is over :



Dept = "ما يُستدان يجب أن يرد إلى صاحب المال"

Recovery of aerobic system after exercise



Used **within minute during exercise** or for aerobic metabolism should be replenished by breathing extra amount of O₂ over and above the normal need.

2 Liters > يتم استرجاعهم عن طريق التنفس السريع مباشرة بعد التمارين
9 Liters > 40 min يتم استرجاعه بعد

Recovery of muscle glycogen

- Depletion of glycogen stores by heavy exercise needs days to be replenished.
- On **high Carbohydrates** diet, recovery occurs in **2 days**.
- On **high fat, high protein** or on no food all show very **little** recovery.

- Athlete should have **high carbohydrates** diet before exercise.
- Not to participate in exhausting exercise during 48 hours preceding the event.

نحتاج إلى يومين لتعويض الجلايكونين بشرط إدخال الكربوهيدرات إلى النظام الغذائي بينما لو كان النظام الغذائي يعتمد على البروتين أو الدهون فقط فإن المدة ستكون أطول لذلك الأشخاص الرياضيين يحتاجون إلى تناول كميات كبيرة من الكربوهيدرات بعد أداء التمارين



Physical & Physiological Factors Affecting Athletics' Performance



Body fluids and salts



Smoking



Heart disease and old age



Nutrients



Disease



Drugs and athletes



Oxygen availability



Glucose availability



Sleep

Gender



Age



Nutrients used during muscle activity

During early stages of exercise and intense muscle activity :

- Body use CHO of muscle glycogen and blood glucose ,also fats as fatty acids and acetoacetic acid very little amino acids.
- In endurance athletic (last longer than 4-5 hours and during exhaustion muscle) **glycogen** is depleted and muscle **depend on fats**.



CHO energy comes from **muscle** and **liver** glycogen.



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

إذا كانت مدة
التمرين طويلة
(٤-٥ ساعات) ،
تتفد كمية
الجلايكوجين ثم يبدأ
الجسم بحرق
الدهون يليها
البروتينات.

Effects of Smoking on pulmonary ventilation in exercise

Nicotine causes:

1. Constriction of terminal bronchioles.
2. Increases resistance of air flow into and out lung.
3. Paralyse the cilia on respiratory epithelial cell surface.

Smoke irritation causes:

- 1- increased fluid secretion into bronchial tree.
- 2- swelling of epithelial linings.



- All lead to fluid & waste accumulation and **level of performance reduced**.
- Chronic smokers may develop **Emphysema** “obstruction of bronchioles / chronic bronchitis / destruction of alveoli” so slight exercise cause respiratory pain.

Effects of heart disease and old age on athletic performance

Cardiac disease :

- Reduce cardiac output (C.O)
- Reduce muscle power
- Patient with **CHF** (chronic heart failure) can not climb the bed

Old age:

- There is **50%** decrease in C.O between 18-80 years.
- Decrease in breathing capacity.
- Decrease muscle mass and power



- Youth are better in sport performance than elderly footballer getting old may retire or be a coach.

(C.O) :The volume of blood pumped by the heart per minute

Exercise for 1 hour during endurance athletic event causes 5-10 pounds of weight loss in hot humid atmosphere due to sweat loss to remove metabolic waste heat, if sweating is intense may cause **dehydration**

Dehydration leads to:

- Constant rise in body temperature.
- Increase in heart-rate.
- Decreased stroke volume and cardiac output.
- Loss of enough sweat reduce performance.

[5 -10%] loss of weight lead to **cramps, nausea** and serious effects so should be replaced by:

- Sodium tablets or supplemental fluids contain potassium.
- Sodium in form of fruit juice.

Nausea : غثيان
Cramps : تشنجات

Aldosterone is a steroid hormone secreted by adrenal gland serves as the principal regulator of the salt and water balance of the body The biological action of aldosterone is to increase the retention of sodium and water and to increase the excretion of potassium by the kidneys [sodium-retaining hormone].

Dr.Faten
asked: what is
the effect of
aldosterone?

- Caffeine **increase** athletes performance.

- Anabolic steroids and androgens (Example :Testosterone) :
 - These are used by some athletes(of both sexes)
 - 1) to increase their muscle mass
 - 2) allow the athlete to train harder
 - 3) enhance their physical performance
 - Their use in sport competitions is illegal.

They have harmful side-effects such as :

- Raised blood pressure .
- They increase risk of heart attacks due to hypertension.
- In males male sex hormones decrease testicular functions & decrease natural testosterone.
- In women develop facial hair, stoppage of menses, ruddy skin and bass voice.

Anabolic steroids = هرمونات

Amphetamine & cocaine

Improve performance but overuse reduce performance they are psychic stimuli.

Reaction of these drugs with epinephrine and norepinephrine secreted during exercise cause death by ventricular fibrillation.

Amphetamine :
stimulate brain activity > impulses to muscles
> better performance.

Stimulants

- Increase reaction speed (decrease reaction-time)
- reduce perception of pain
- raise aggression
- They are highly addictive

Side-effects :

High blood pressure
Cardiac problems
Strokes
Liver disease

Narcotic analgesics

These are **pain killers** which athletes use to mask pain from an injury or overtraining .They are also highly addictive and cause withdrawal symptoms when the athlete stops using them.

Stimulants = منشطات
Narcotic analgesics = مسكنات الألم
highly addictive = الإدمان مثل الإدمان على الكوكايين

Factors Affecting athletic Performance

Body fitness prolongs life:

Multiple studies shows that body fitness exercise & weight control have additional benefit of prolonged life between(50-70)

Body fitness reduce insulin resistance and type 2 Diabetes.

Reduce CVD, Heart attacks, Brain, Stroke and Kidney disease due to low blood pressure low cholesterol,
Low LDL high HDL.

Improved body fitness reduces the risk of cancer breast prostate and colon.

Improved body fitness reduces obesity

Low (Low density lipoprotein) &High (High density lipoprotein)
يقلل الدهون الضارة ويرفع الدهون المفيدة

CVD = Cardiovascular disease.

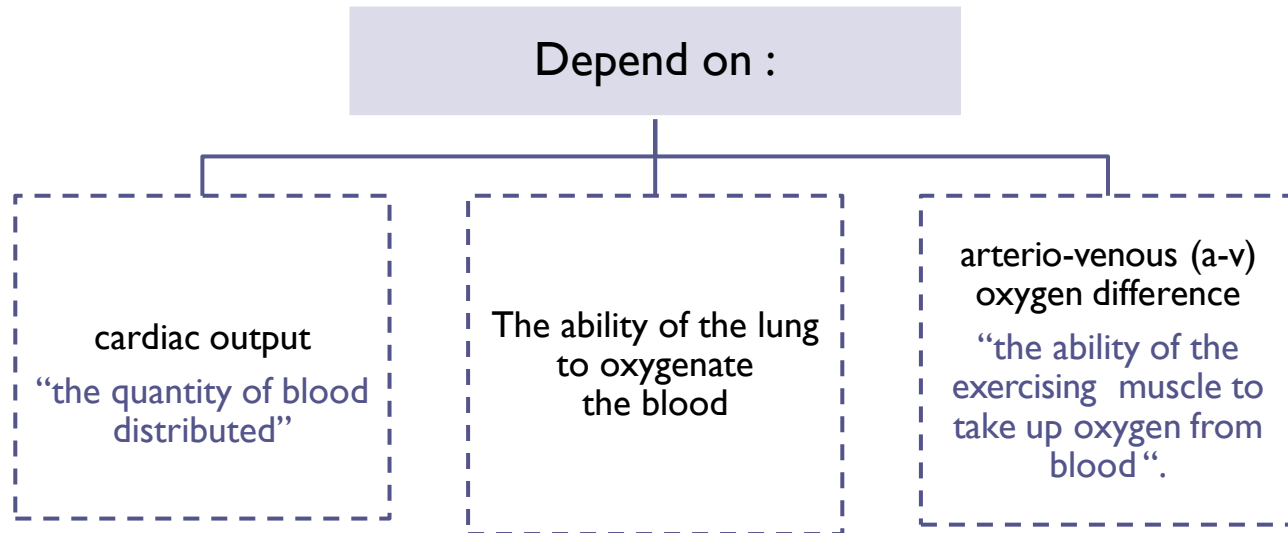


Glucose availability:

- Plasma glucose is maintained by an equal rate of glucose appearance (**entry into the blood**) and glucose disposal (**removal from the blood**).
- In the healthy individual, rate of appearance and disposal are essentially **equal** during exercise of moderate intensity and duration.
- prolonged , intense exercise can result in **a fall in blood glucose level and the onset of fatigue .**
- During exercise , rate of glucose appearance depends mainly on the **liver** (**glycogenolysis & gluconeogenesis**) , and to a lesser extent , on absorption from the **gut** .

Factors Affecting athletic Performance

Oxygen availability :



Gender :

- Because of difference between genders :

- In **body build**
- physical ability
- Menstruation

men can perform better than women in contact sports such as boxing , rugby(type of ball game) and wrestling(fighting game).

women may perform differently at different times during their monthly menstrual cycle.

Sleep :

- Sufficient , restful sleep is important for physical and mental health .
- Lack of sleep makes the athlete nervous and irritable and deteriorates the physical performance.

Factors affecting athletes performance

Disease:

Musculoskeletal disease

“sprain , disk“

General disease

“bronchial asthma , colds , flu”

“all may affect muscular exercise performance”

Strain is a stretching or tearing of **muscle** or **tendon**.

Sprain is a stretching or tearing of **ligaments** ."the tough bands of fibrous tissue that connect two bones together in your joints.

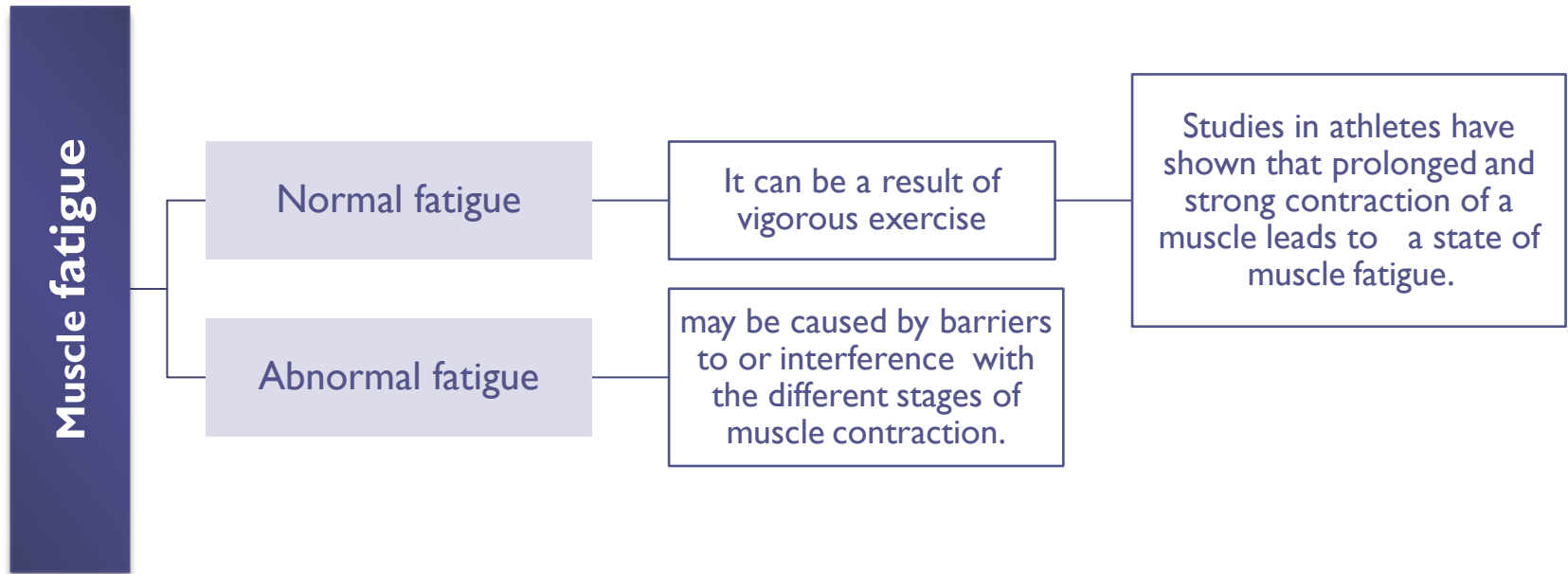
“The most common location for a sprain is in your ankle”



Dr.Faten asked :
what is the difference between
sprain and strain?

Muscle fatigue(physical fatigue)

- **Muscle fatigue(physical fatigue) :**
It is the decline in ability of a muscle to generate force.



Causes of muscle fatigue

1- Glycogen depletion :

- Studies in athletes show that muscle fatigue increases in **direct proportion** to the rate of muscle glycogen depletion.
- Lack of **ATP** and **creatine phosphate**

"When these energy substrates are depleted during exercise, resulting in a lack of intracellular energy sources to fuel contractions & the muscle stops contracting"

Glycogen depletion > also loss of C-P & ATP caused muscle fatigue, but the glycogen is the most important

2- Interruption of blood flow :

- through a contracting muscle leads to almost complete muscle fatigue in one or more minutes because of loss of nutrient supply and oxygen loss.

Contraction > constriction of blood vessels > low blood flow > accumulation of lactic acid > muscle fatigue.

3-Neuromuscular Fatigue :

- Reduced neurotransmitter release= (Reduced **Ach** release)

- Fatigue also can occur at the **neuromuscular junction**. After prolonged muscle activity, transmission of nerve signals through the neuromuscular junction **diminishes** due to **diminished acetylcholine vesicles**. This prevents the nerve impulse from transmitting through neuromuscular junction to the muscle fiber and diminishes muscle contraction
- Some evidence suggests calcium retention within the sarcoplasmic reticulum, may lead to a decrease in calcium available for muscle contraction.

مثل مانعرف : العضلة تعتمد بانقباضها على Ach المنبعث من النهايات العصبية ، نتيجة لتلقي محفزات متتالية بسرعة فائقة يتم إفراز كميات كبيرة منه وبالتالي ينتهي، ويتوقف وصول المحفزات للعضلة .

Neuromuscular fatigue > when the nerve impulse comes in too high frequency which cause explosion in acetylcholine vesicle > then lack of acetylcholine > then no neuromuscular transmission

أيضاً انقباض العضلة يتطلب تدفق الكالسيوم من ال sarcoplasmic reticulum ، لكن عند احتباسه داخلها لن تنقبض العضلة.

Causes of muscle fatigue

4- Metabolic changes :

- Metabolic changes are associated with fatigue
"Lactic acid accumulation in the muscles often is associated with muscular fatigue."

Metabolic changes > the most dangerous is the lactic acid accumulation > the dangerous not in the lactic acid itself, but in the H which release when cracking lactic acid > which increased the acidity of the muscle > decrease the amount of Ca^{++} "SR يقلل كمية الكالسيوم اللي تطلع من" > which decrease the muscle performance

Lactic acid accumulation



The accumulation of hydrogen ion generated by lactic acid



decreases muscle pH and increase intracellular acidity of muscles



muscle acidity can **lower** the sensitivity of contractile apparatus to Ca^2



which impairs the cellular processes that produce energy



Impair muscle contraction

What is it ?

Over-Training Syndrome is the state where the athlete has been repeatedly stressed by training to the point where rest is no longer adequate (sufficient enough) to allow recovery.

When sufficient rest is **not** included in a training program then **regeneration** cannot occur. If this imbalance between excess training and inadequate rest persists then athletic performance will decline, simply because it is rest that makes you stronger.

What are the symptoms of it in general?

A collection of emotional, behavioral, and physical symptoms due to overtraining that has persisted for weeks to months.

Classification:

The overtraining syndrome is classified as a neuro-endocrine disorder. In which the normal fine balance in the interaction between the autonomic nervous system and the hormonal system is disturbed.

- It may impair an athlete during training or daily work, with signs of :

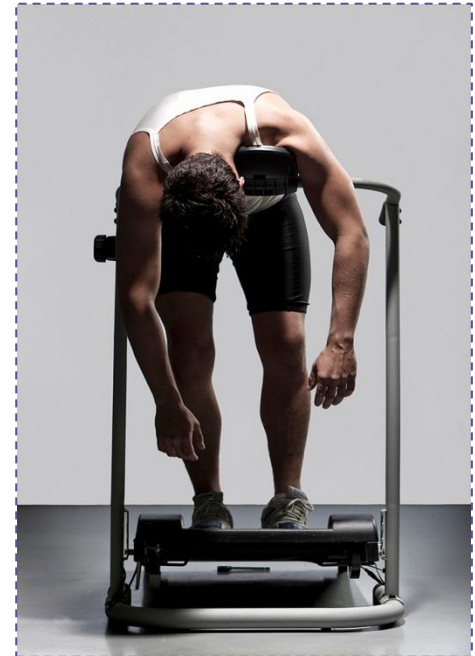
Fatigue which may limit workouts and may be present at rest

The athlete becomes:

- Moody (mood swings)
- Easily irritated
- Inattentive due to decreased concentration.
- Insomniac due to altered sleeping patterns.
- Depressed or even lose their competitive desire
- Some will report decreased appetite (loss of appetite) and weight loss.

Physical symptoms:

- Persistent muscular soreness.
- Increased frequency of **viral illnesses**.
- Increased incidence of injuries.
- In some, **increased cortisol levels** (the body's "stress" hormone).
- A decrease in testosterone
- Altered immune status
- An increase in muscular break down products



the person feels tired even though he's hasn't moved all day

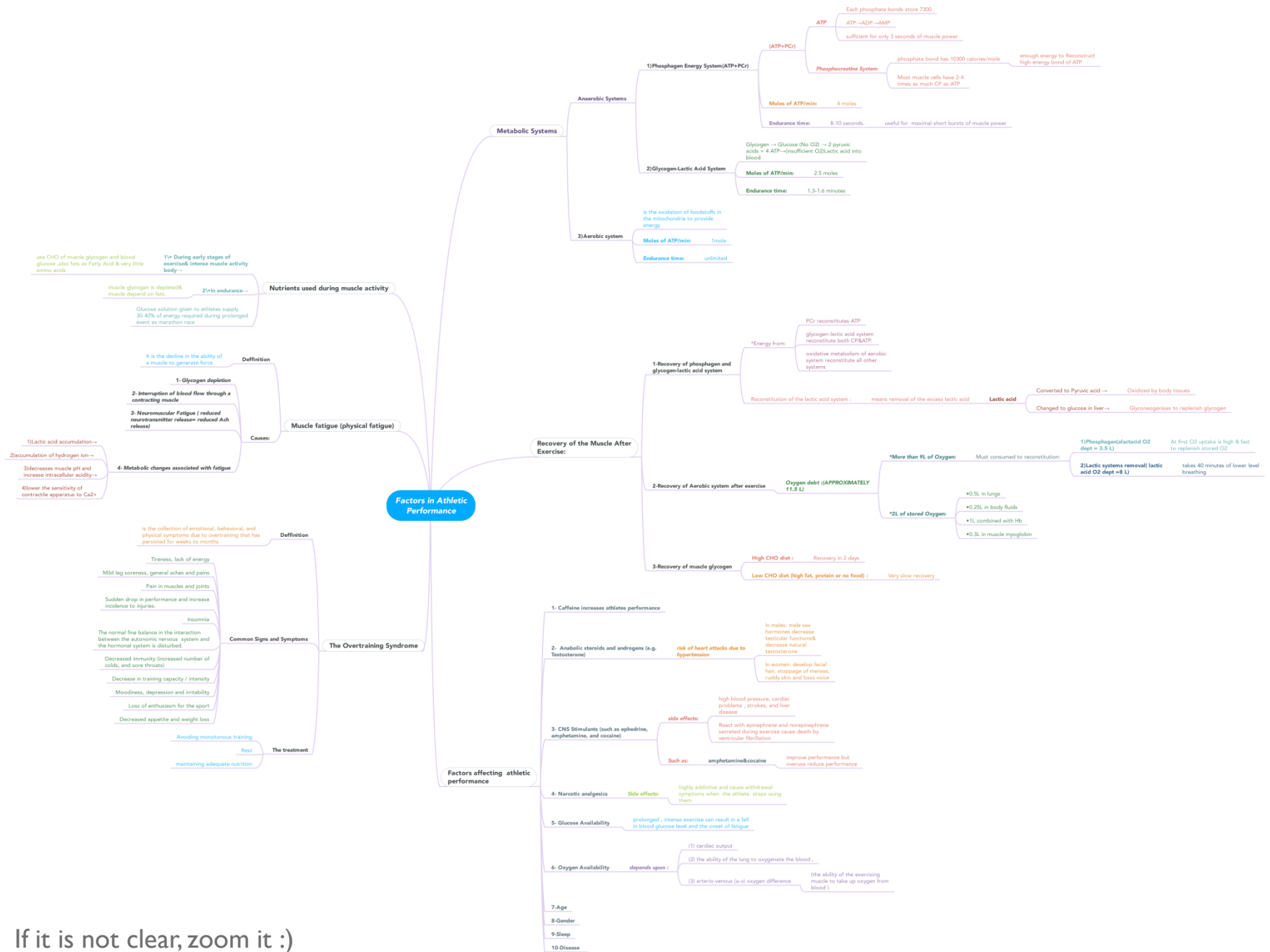
muscular soreness = ألم في العضلات

Over-Training Syndrome Treatment

- [Treatment “Rest “] :
 - If sufficient rest is not included in a training program then regeneration cannot occur. If this imbalance between excess training and inadequate rest persists then performance will decline.
 - The longer the overtraining has occurred, the more rest required.
 - If the overtraining has only occurred for a short period of time (3 - 4 weeks) then interrupting training for (3 - 5 days) is usually sufficient rest to get the body back to normal.
 - The second treatment is **avoiding monotonous training** and maintaining adequate nutrition are other recommendations for prevention.

• Avoiding monotonous training :

مثلاً لاعب أثقال نغير له نوع التمرين لتمارين هوائي عشان يحافظ على أدائه وبنفس الوقت يكسر رتابة التمارين



If it is not clear, zoom it :)

QUIZ

- عمر العتيبي
- رواف الرواف
- حسن البلادي
- عمر الشهري
- عادل الشهري
- عبدالله الجعفر
- عبدالرحمن البركة
- خليل الدريبي
- عبدالعزيز الحماد
- عبدالعزيز الغنايم
- عبدالمجيد العتيبي
- عبدالعزيز رضوان
- خولة العماري
- الهنوف الجلعود
- إلهام الزهراني
- رغد النفيسة
- ملاك الشريف
- نورة القحطاني
- منيرة الحسيني
- منيرة السلولي
- فتون الصالح
- أفنان المالكي
- ربي السليمي
- منيرة العمري
- عائشة الصباغ
- شهد الدخيل
- نوف التويجري
- لينة الشهري
- روان الضويحي