

# **Physical and Physiological Factors Affecting athletic Performance**

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# Objectives

## 1- At the end of this lecture the student should:-

- 1-Know the 3 metabolic systems exceedingly important in understanding the limits of physical activity
- 2- know recovery of the aerobic system after exercise and O<sub>2</sub> dept.
- 3-Understand the Effects of smoking on pulmonary ventilation in exercise & effect of heart disease
- 4-Know effect of some drugs on athletes performance
- 5-Know the causes and effect of fatigue on sport performance
- 6- Identify overtraining syndrome

Reference book/ Guyton human physiology

There are 3 metabolic systems exceedingly important in understanding the limits of physical activity.

These are:

1-Phosphagen system

2-Glycogen-lactic acid system

3-Aerobic system

# Adenosine Triphosphate:-

Adenosine-PO<sub>3</sub> ~ PO<sub>3</sub> ~PO<sub>3</sub>

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

## Phosphocreatine-creatine system= Creatine-phosphate system(creatine ~ $\text{Po}_3$ )

-Contain high energy phosphate bond has 10300 calories/mole

S0 CP provide enough energy to reconstruct high energy bond of ATP

-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 .Therefore, energy of muscle CP is available for contraction just as stored energy of ATP.

# Phosphagen energy system

Phosphagen energy system:- it is 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.

# Glycogen-lactic acid system

Anaerobic metabolism( glycolysis):-

-During glycolysis glycogen of the muscle split into glucose without use of O<sub>2</sub>

-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 O<sub>2</sub> will form more ATP(oxidative stage)

- When there is insufficient O<sub>2</sub> most of pyruvic acid converts into lactic acid ,diffuse to blood stream.
- 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( ½ 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)



# Aerobic process:-

Oxidation of foodstuffs glucose, AA,FA in the mitochondrai in presence of O<sub>2</sub> produces energy that coverts AMP to ADP to ATP  
-supply enerfor unlimited time  
(figure 84-1,table 84-1)



## Moles of ATP/min

-phosphagen system

4 moles

-Glycogen-lactic acid system 2.5 moles

-Aerobic system

1 moles

## Endurance time

-phosphagen system

8-10 seconds

-Glycogen-lactic acid system

1.3-1.6 minutes

-Aerobic system (unlimited time as long as nutrients last)

## Recovery of muscle metabolic systems after exercise:-

- Energy from CP reconstitute ATP
- Energy from glycogen-lactic acid system reconstitute both CP&ATP
- Energy from oxidative metabolism of aerobic system reconstitute all other systems(glycogen-lactic acid system & CP&ATP)
- Lactic acid causes fatigue so it is removed in 2 ways:-

(lactic acid system reconstitution means removal)

1-portion converted into pyruvic acid and oxidated by tissues

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

# Recovery of aerobic system after exercise:

## 1-Oxygen Debt:-

- this is 11.5litres of O<sub>2</sub> should be repaid after exercise is over
- First portion of O<sub>2</sub> debt is called( alactacid O<sub>2</sub> debt about 3.5 L)
- The later portion is called (lactic acid O<sub>2</sub> debt = 8 Litres)

-2 LITERS stored O<sub>2</sub> ( 0.5 L in lungs+0.25L dissolved in body fluids+1 l combined with Hb +0.3 L stored in muscle myoglobin) used within minute during exercise or for aerobic metabolism should be replenished by breathing extra amounts of O<sub>2</sub> over & above the normal needs

-9 L more O<sub>2</sub> must consumed to reconstitute phosphagen system and lactic acid system

-At first O uptake is high & fast to replenish stored O<sub>2</sub> & phosphagen system ,then 40 minutes of lower level breathing O<sub>2</sub> for lactic acid system removal

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## **-Recovery of muscle glycogen**



**-Depletion of glycogen stores by heavy exercise needs days to be replenished**

**-On high CHO diet ,recovery occurs in 2 days**

**-On high fat, high protein all show very little recovery**

**Message: \_**

**1- athlete should have high CHO diet before exercise**

**2- not to participate in exhausting exercise during 48 hours preceding the event**

## **Nutrients used during muscle activity:-**

**- During early stages of exercise & intense muscle activity body use CHO of muscle glycogen and blood glucose ,also fats as F.A & acetoacetic acid & very little A.A.**

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

**-In endurance athletic 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 energy required during prolonged event as marathon race**

**-Effects of smoking on pulmonary ventilation in exercise;-**

**-1-Nicotine causes constriction of terminal bronchioles&increases resistance of airflow into&out lung**

**2-smoke irritation causes increased fluid secretion into bronchial tree& swelling of epithelial linings**

**-3- nicotine paralyse the cilia on respiratory epithelial cell surface**

**-all lead to fluid & debris accumulation& level of performance reduced**

**-Chronic smokers may develop emphysema(obstruction of bronchiols+chronic bronchitis+destruction of alveoli) so slight exercise cause respiratory distress**

## **-Effects of heart disease and old age on athletic performance:-**

- Cardiac disease reduce C.O& reduce muscle power**
- patient withCHF can not climb the bed**

**Age-There is 50% decrease in C.O between 18-80 years& decrease in breathing capacity,muscle mass & power with age**

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



## **-Effect of body fluids and salts in exercise**

- 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:

1- constant rise in body temperature

2- increase in heart-rate

3- decreased stroke volume and cardiac output

4- Loss of enough sweat reduce performance

-5-10% loss of weight lead to cramps, nausea & serious effects

so should be replaced by:-

-sodium tablets or supplemental fluids contain potassium and

sodium in form of fruit juice

- **What is the effect of aldosterone?**

## -Drugs and athletes



1- Caffeine increase athletes performance

2- Anabolic steroids and androgens ( e.g., Testosterone ) :

These are used by some athletes ( of both sexes ) to increase their muscle mass, allow the athlete to train harder and thereby 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

.

### **-Stimulants**

Stimulants increase reaction speed ( i.e., decrease reaction-time ) ,  
reduce perception of pain and raise aggression

They are highly addictive and have side-effects including high blood pressure,  
cardiac problems , strokes, and 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.

- amphetamine&cocaine improve performance but overuse reduce performance they  
are psychic stimuli

-reaction of these drugs with epinephrene and norepinephrene secreted during exercise  
cause death by ventricular fibrillation

## **Body fitness prolongs life:-**

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

**Reasons:-**

**1-reduce CVD, heart attacks,brain stroke and kidney disease due to low blood pressure, low blood cholestrol ,low LDL, and high HDL**

**-Body fitness reduce insulin resistance and typy 2 diabetes**

**-Improved body fitness reduces the risk of cancer breast mprostatemand colon**

**- Improved body fitness reduces obesity**



## - 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;
- \* However, 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 .

## - Oxygen Availability

Which depends upon →

- (1) cardiac output (the quantity of blood distributed by the heart ) ,
- (2) the ability of the lung to oxygenate the blood ,
- (3) arterio-venous (a-v) oxygen difference ( i.e., the ability of the exercising muscle to take up oxygen from blood ).



## -Gender

Because of difference between genders of in body build and physical ability , men can perform better than women in contact sports such as boxing , rugby and wrestling .

(ii) Menstruation : 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 , & deteriorates the physical performance

## -Disease

Musculoskeletal disease e.g., sprain , disk etc , or

General disease e.g., bronchial asthma , colds , flu , etc All may affect muscular exercise performance

**What is the difference between strain and sprain?.**

## **Muscle fatigue(physical fatigue)**

- It is the decline in ability of a muscle to generate force.
- It can be a result of vigorous exercise but abnormal fatigue may be caused by barriers to or interference with the different stages of muscle contraction.
- Studies in athletes have shown that prolonged and strong contraction of a muscle leads to a state of muscle fatigue

### **Causes**

**1-Glycogen depletion:** Studies in athletes gave shown that muscle fatigue increases in direct proportion to the rate of muscle glycogen depletion

Also, 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.

**2-Interruption of blood flow** through a contracting muscle leads to almost complete muscle fatigue in 1 or more minutes because of loss of nutrient supply and oxygen loss.



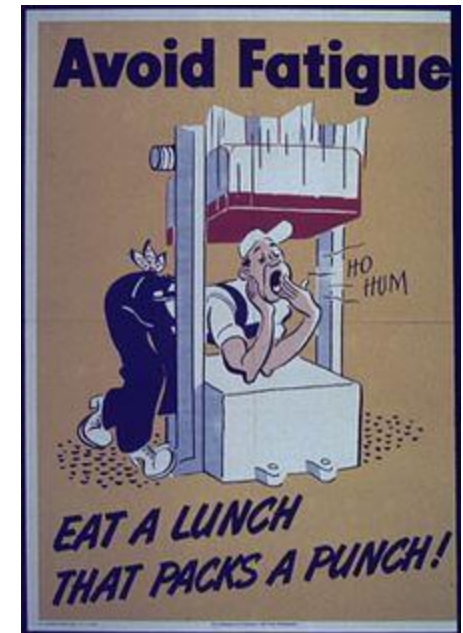
### 3-Neuromuscular Fatigue ( reduced neurotransmitter release= reduced Ach release)

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& diminishes muscle contraction

Some evidence suggests calcium retention within the sarcoplasmic reticulum , may lead to a decrease in calcium available for muscle contraction.

### 4- Metabolic changes associated with fatigue

Lactic acid accumulation in the muscles often is associated with muscular fatigue. The accumulation of hydrogen ion generated by lactic acid decreases muscle pH and increase intracellular acidity of muscles which impairs the cellular processes that produce energy and muscle contraction, muscle acidity can lower the sensitivity of contractile apparatus to  $Ca^{2+}$ .





# THE OVERTRAINING SYNDROME



# Overtraining Syndrome

Overtraining can best be defined as the state where the athlete has been repeatedly stressed by training to the point where rest is no longer adequate to allow for recovery.

- The "overtraining syndrome" is the collection of emotional, behavioral, and physical symptoms due to overtraining that has persisted for weeks to months
- 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.

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

- 1-Fatigue which may limit workouts and may be present at rest.
- 2-The athlete becomes moody, easily irritated, decreased concentration have altered sleep patterns,
- 3-The athlete becomes depressed, or lose the competitive desire
- 4-Some will report decreased appetite and weight loss.
- 5-Physical symptoms include persistent muscular soreness, increased frequency of viral illnesses, and increased incidence of injuries.

6-In some, increased cortisol levels (the body's "stress" hormone).

7-A decrease in testosterone

8- Altered immune status

9- An increase in muscular break down products have also been identified.

10- 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 .

**-The treatment for the overtraining syndrome is :-**

**1- REST** .The longer the overtraining has occurred, the more rest required. If the overtraining has only occurred for a short period of time (e.g., 3 - 4 weeks) then interrupting training for 3 - 5 days is usually sufficient rest

2-Avoiding monotonous training and maintaining adequate nutrition are other recommendations for prevention.