



Muscle Adaption to Exercise

Color index

- **Important**
- Further Explanation

Objectives

- **Strength, power, and endurance of muscles**
- **Effect of athletic training on muscles and muscle performance**
- **Muscle hypertrophy**
- **Fast-twitch and slow-twitch muscle fibers**
- **Respiration in exercise**
- **Oxygen consumption and pulmonary ventilation in exercise**
- **Effect of training on vo2 max**
- **Cardiovascular system in exercise**
- **Work output, oxygen consumption, and cardiac output during exercise**
- **Effect of training on heart hypertrophy and on cardiac output**
- **Role of stroke volume and heart rate in increasing the cardiac output**
- **Body heat in exercise & heatstroke**

Definitions :

Muscle Strength:

Refers to the amount of force a muscle can produce

Note: A maximal contractile force, Normally 3 -4 kg/cm² (Size of muscles influence)

Mechanical Work = force applied by the muscle X distance

Mechanical Power = amount of work that the muscle performs in period of time (kg-m/min)

Muscle Endurance:

Ability of muscles to sustain repeated contractions against a resistance for period of time.

Note: It depends on glycogen stored in the muscle

Muscle Strength Components

Mechanical Strength

Definition: It's the **maximum force a muscle can exert.**

Depends On: The muscle cross-sectional area.

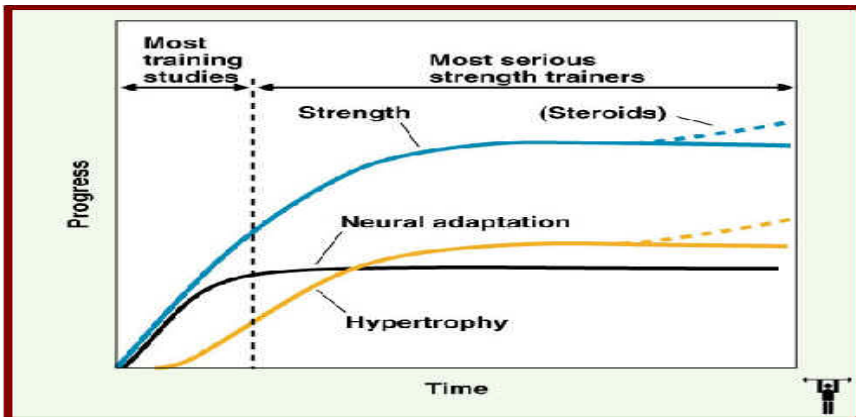
- So if after a period of training, an athlete increases his muscle size by 50 % , he will also increase the force the muscle can develop by 50% .

Neurological Strength

Definition: It's how many of the anterior horn cells(AHC) motor neurons of the spinal cord supplying that muscle are recruited + frequency of action potentials in them to supply the muscle.

Case: Diseases involving the AHCs (e.g., poliomyelitis) the number of active AHCs may be considerably reduced which causes decreased muscle performance.

A severely depressed person or athlete) , who lost his motivation may ,unconsciously, recruit less AHCs than normal which causes decreased performance .



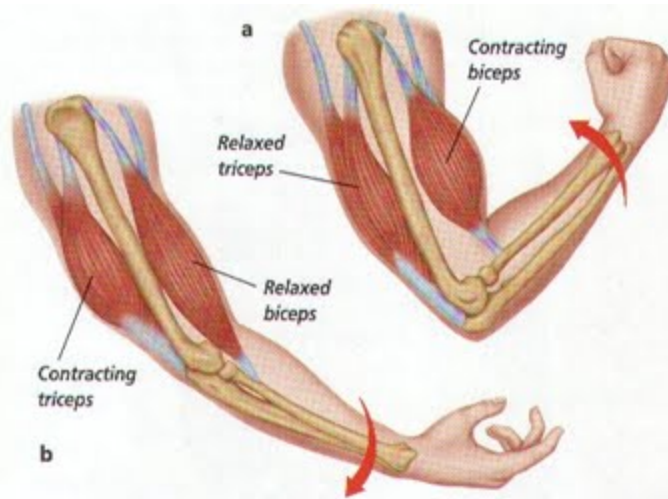
Muscle Power

- When muscles contract or stretch while moving a load, they do work , and energy is transferred from one form to another.
- The power of muscles refers to how quickly the muscles can do this work and transfer the energy.

Work = Force × Distance

Power = $\frac{\text{Work}}{\text{Time}}$

The shorter the time used to perform a piece of work , the more power is needed
علاقة عكسية



Effects of Exercise on The Body



Muscle &
Muscle
Performance



Body Heat



Cardiovascular
System



Respiratory
System

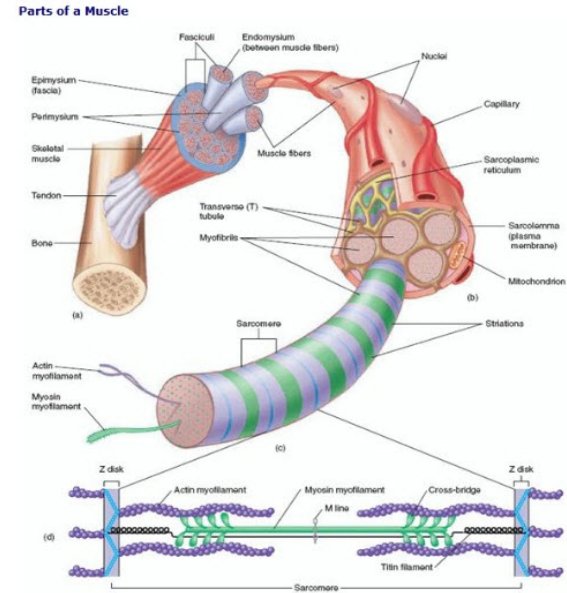


- 6 Maximal muscle contractions sets against a load X 3 days X one week greatly increase in muscle strength, without muscle fatigue.
- 10 weeks training increase strength 30%
- However, muscles function under no load cause little increase in strength



Muscle Hypertrophy

- Exercise hypertrophy is due to increase in **contractile protein** (number of actin & myosin filaments in each muscle fibre = muscle cell)
- When number of contractile proteins increases sufficiently, myofibrils **split** within each muscle fibre to form **new myofibrils**, so it is mainly great increase in the number of additional myofibrils that causes muscle fiber to hypertrophy. That is, hypertrophy results primarily from the **growth of each muscle cell**, rather than an increase in the number of cells.
- With training muscles hypertrophied **30- 60 %**

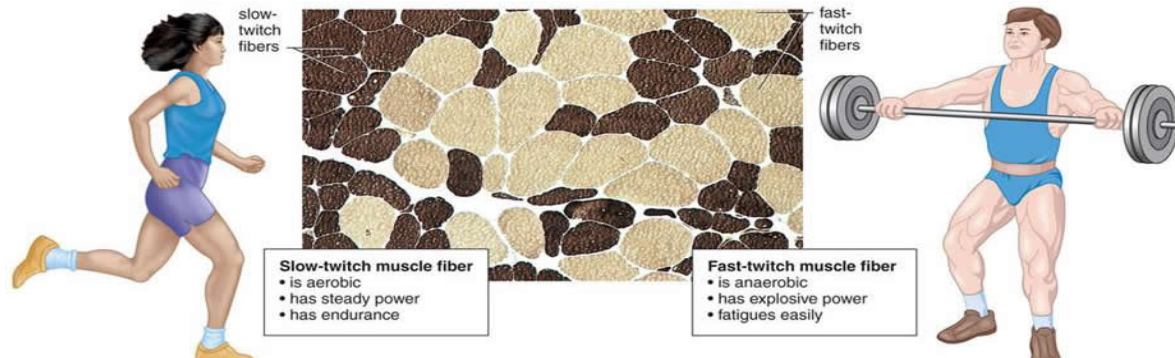


Changes in hypertrophied muscle:

- Increased myofibrils
- Increased 120 % in mitochondrial enzymes
- Increase ATP and phosphocreatine
- Increased 50 % in stored glycogen
- Increased 75 -100 % in stored triglyceride
- Increased oxidation rate 45 %
- Increased capability of aerobic and anaerobic metabolic systems

Muscle Fibers

	Slow Twitch “ Aerobic ”	Fast Twitch “ Anerobic ”
Fibers Color	Red Fibers	White Fibers
Myoglobin Amount	HIGH	LOW
Fibers Characteristics	Small & Innervated with Small Motor Neuron	Large & Innervated with Larger Motor Neurons
Sarcoplasmic Reticulum	Extensive sarcoplasmic reticulum for rapid release of calcium	
Mitochondria	Large Number, to support HIGH oxidative metabolism	Fewer number, cause oxidative metabolism is LESS important
Capillary Density	Higher capillarity	Lower Capillarity
Suited Activity	Prolonged endured activity Ex: Marathon runners	Forceful Rapid Contraction Ex: Sprinters
Duration of Use	Hours	< 5 Minutes
Glycolytic Enzymes	High	Low
Muscles used	Leg muscles	Gastrocnemius muscle



Respiratory System

Respiration in Exercise

- Oxygen Consumption VO_2 & Pulmonary ventilation VE in exercise
- VO_2 at rest is about 250 ml/min
- However !!! at Maximal efforts: VO_2 and VE increase about 20-folds between the resting state and maximal intensity.

Vo_2 Max in Exercise

- Vo_2 Max increased only about 10 percent by training, Moreover, other factors may affect it. Such as:
- Chest sizes in relation to body size.
- Increase respiratory muscles force of contraction

O_2 Diffusion Capacity

Increases 3 folds during exercise than at rest due to:-

1-increase of lung blood flow in pulmonary capillaries during exercise at maximum level, this increases surface area for O_2 to diffuse into pulmonary capillaries.

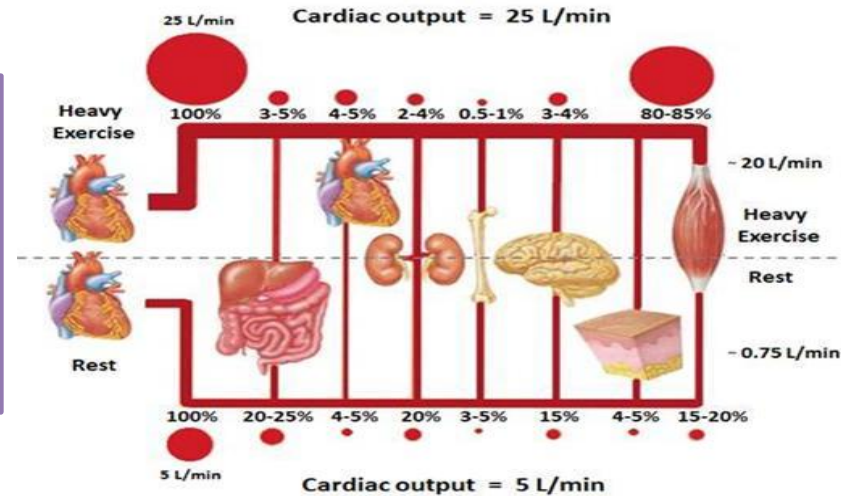
2- Respiration is stimulated by neurogenic mechanisms due to direct stimulation of respiratory center by nervous signals that are also transmitted from brain to muscle to do exercise, sensory signals are also transmitted from contracting muscles and moving joints into respiratory center to stimulate respiration so blood gases during exercise are normal in concentration

Cardiovascular System



During Exercise

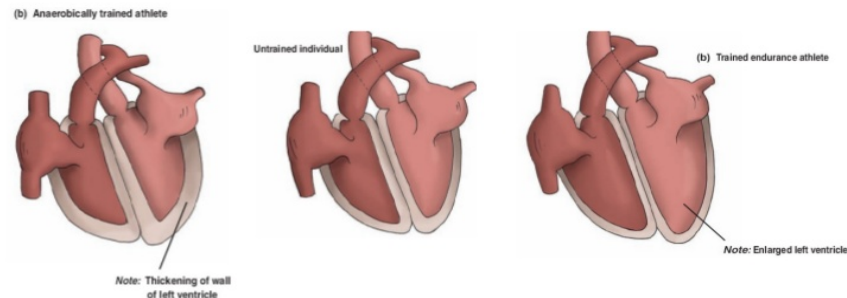
- **Muscle work output increases** oxygen consumption, and increased oxygen consumption in turn dilates the muscle blood vessels, thus increasing venous return and cardiac output



Heart Hypertrophy & Cardiac Output

- Training increases Cardiac Output about 40 % greater than untrained persons, so the heart chambers of marathoners enlarges about 40% in contrast to non trained people.
- The Heart size of a marathoner is **larger** than a normal person's heart.

Cardiovascular Training adaptations – Cardiac Hypertrophy



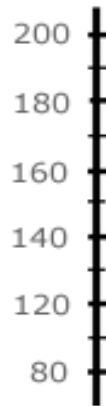
Cardiovascular System



The heart rate increases from 50 to 185 beats/min, an increase of 270%.

Heart Rate

HR (beats/min.)

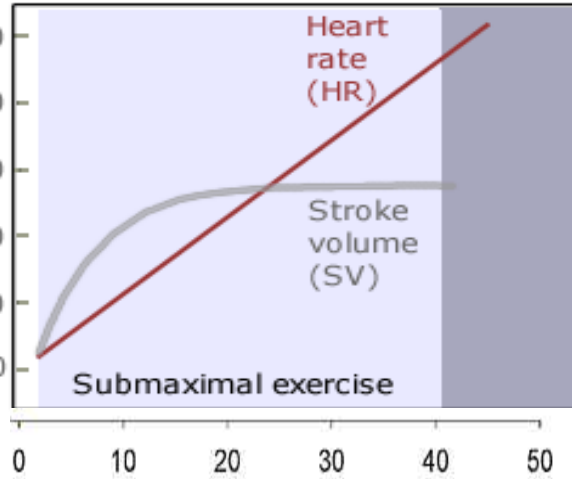


Stroke Volume

SV (ml)



Stroke volume increases from 105 to 162 milliliters, an increase of about 50%

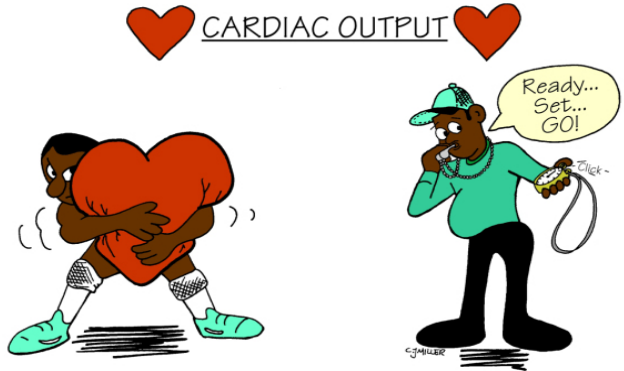


NOTE: Heart rate increase a greater proportion of the increase in cardiac output than does the increase in stroke volume

CARDIAC OUTPUT

Cardiac Output

Cardiac output increases from its resting level of about 5.5 L/min to 30 L/min.

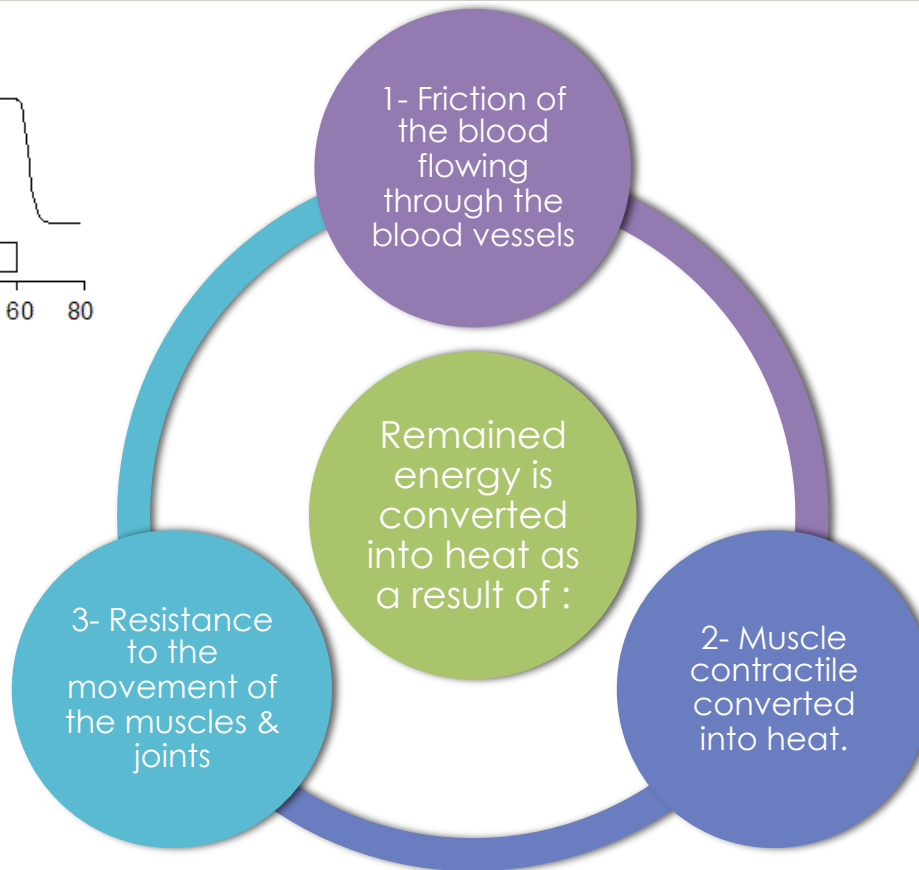
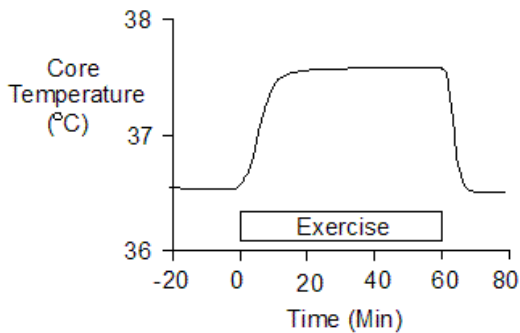


$$CO = HR \times SV$$

Cardiac Output = Heart Rate x Stroke Volume

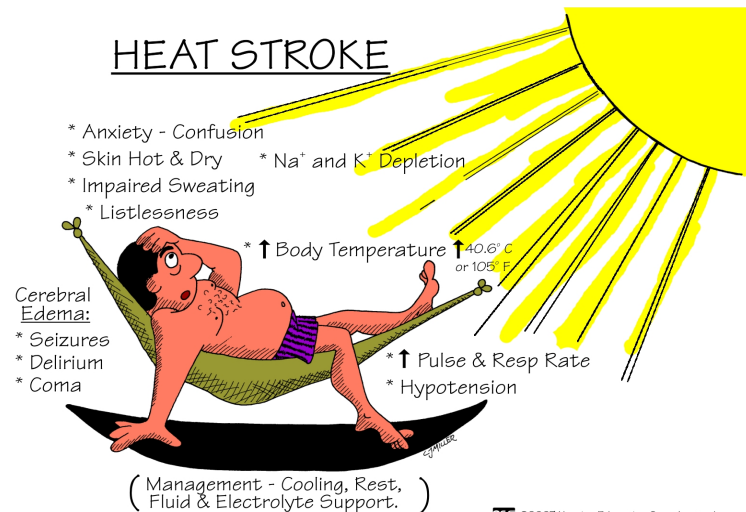
Body Heat

- Almost all the energy released by the body's metabolism is converted into body heat.
- Muscle work uses only 20 - 25 % of the energy released from metabolism.



Heatstroke

- During endurance training body temperature rises 98.6° to 102° or 103°F (37° to 40°C)
- In Hot and humid conditions, the body temperature rises from 106° to 108°F (41° to 42°C)
- Consequently, temperature destructive tissue cells mainly (brain cells)



Heatstroke Symptoms



Treatment of Heatstroke

- Remove all clothing
- Maintain a spray of cool water on all surfaces of the body or continually sponge the body.
- Blow air over the body with a fan.
- Physicians prefer total immersion of the body in water containing a mush of crushed ice if available.

MCQs

1- Muscles Strength: Refers to the amount of force a muscle can :

- A. Use
- B. Increase
- C. Produce
- D. Decrease

2- When muscles contract or stretch in moving a load they do work , and energy is not transferred from one form to another.

- A. True
- B. False

3- During exercising Almost all the energy released by the body's metabolism converted into body heat ?

- A. Heat
- B. Sweat
- C. ATP
- D. Glucose

4- At Maximal efforts VO₂ and VE will increase about ?

- A. 50 fold
- B. 30 fold
- C. 20 fold
- D. 10 fold

5- Muscle work use only ____ of energy?

- A. 15 -20 %
- B. 20-25%
- C. 25-30%
- D. 30-35%

Answers

- 1.C
- 2.B
- 3.A
- 4.C
- 5.B

Thank you for Checking our Team Work

Done by

- Amal Afrah
- Rawan Ghandour
- Rasha Bassas

“Mental will is a muscle that needs exercise, just like the muscles of the body.” Lynn Jennings

