

Muscle adaptation to exercise

Collage of medicine
Physiology Dep.

Objective

- ▶ 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 VO_2 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

Strength, Power, And Endurance Of Muscles

- ▶ Muscles Strength: –the amount of force a muscle can produce
- ▶ – Depends on size of muscles
- ▶ – a maximal contractile force between 3 –4 kg/cm² of a muscle cross-sectional area
- ▶ –E.g a muscle with cross-sectional area 150 cm² cause maximal contractile strength of 525 kilograms applied to tendon of muscle(may cause rupture or avulsion)
- ▶ **Mechanical work of muscle** = force applied by the muscle X distance over which force applied

Strength, Power, And Endurance Of Muscles

- ▶ Muscles Power : amount of work that the muscle performs in a unit period of time (kilogram meters / minute(kg-m/min)

	kg-m/min
First 8 to 10 seconds	7000
Next 1 minute	4000
Next 30 minutes	1700

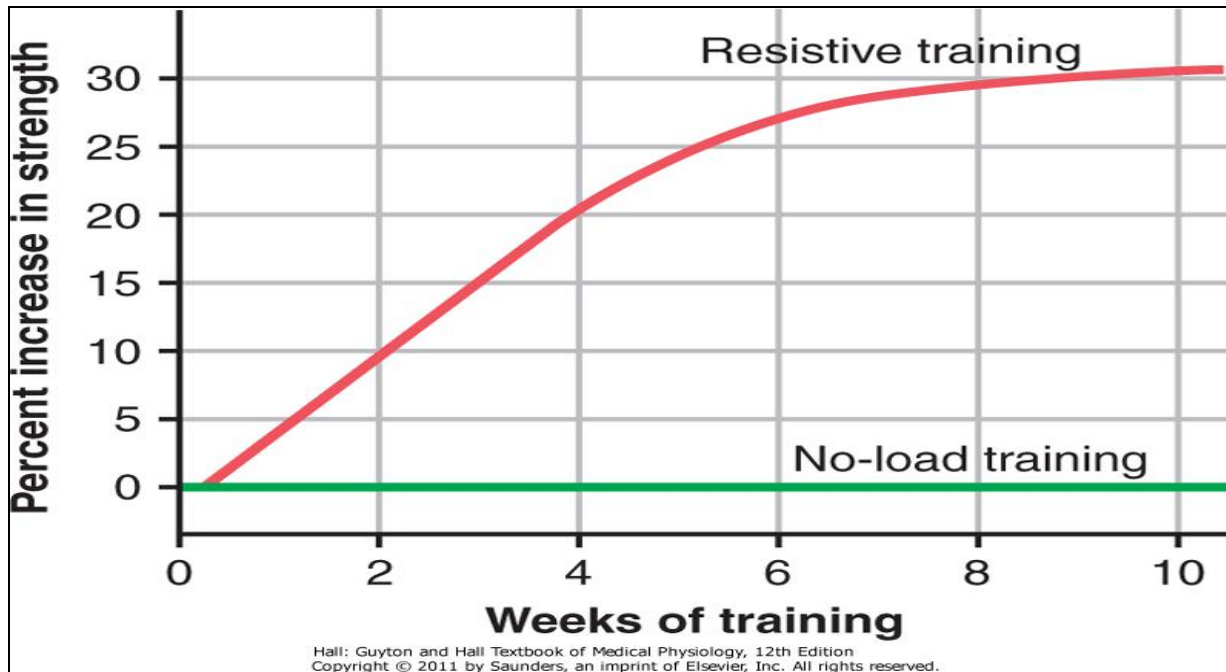
Strength, Power, And Endurance Of Muscles



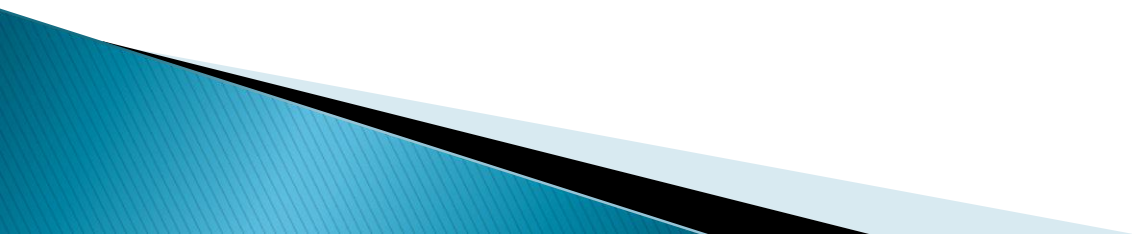
- ▶ **Muscles Endurance**:- Ability of muscles to sustain repeated contractions against a resistance for period of time.
- ▶ depends on glycogen stored in the muscle before exercise

Effect of Training on Muscles and Muscle Performance

- ▶ Maximal Resistance Training:
- ▶ -Muscle exercise for hours without load increase little in strength
- ▶ 6 maximal muscle contractions X 3 sets 3 days X one week increase in muscle strength, without muscle fatigue.



Approximate effect of optimal resistive exercise training on increase in muscle strength over a training period of 10 weeks.





Muscle Hypertrophy:

-Increase in bulk+mass+strength

- ▶ With training muscles hypertrophied 30– 60 %
- ▶ Due to ↑ diameter of the muscle fibers rather than ↑ number of fibers)
- ▶ Changes in hypertrophied muscle:
 - ▶ ↑ myofibrils
 - ▶ ↑ 120 % in mitochondrial enzymes
 - ▶ ↑ ATP and phosphocreatine
 - ▶ ↑ 50 % in stored glycogen
 - ▶ 75 –100 % ↑ in stored triglyceride
 - ▶ Increased anaerobic& aerobic metabolic capability ,specially oxidation rate ↑ 45 %

Fast-Twitch and Slow-Twitch Muscle Fibers

- ▶ Fast-twitch fibers: forceful and rapid contraction

E.G gastrocnemius muscle as in jumping

- ▶ Slow-twitch muscle: for prolonged muscle activity

E.G leg muscle (soleus)

fast-twitch fibers deliver power for seconds to a minute

- **slow-twitch fibers** provide endurance, prolonged strength of contraction minutes to hours.

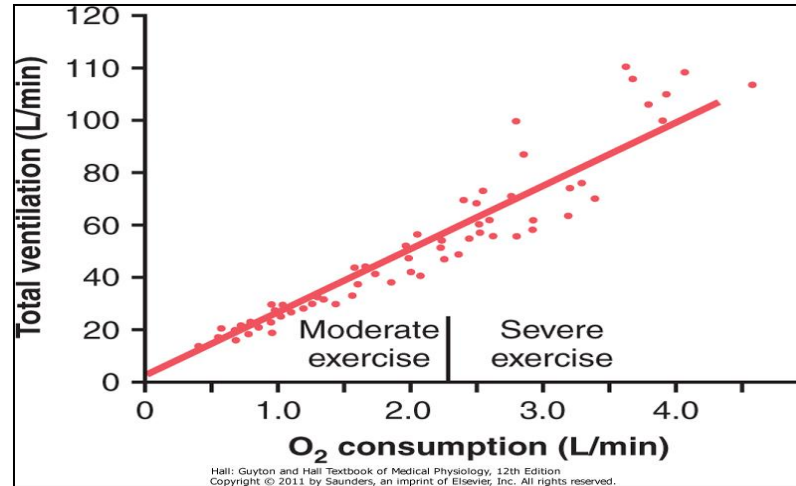
– What is the differences between the fast-twitch and the slow-twitch fibers Read ?[Guyton & Hall: Textbook of Medical Physiology 12E](#)

Respiration In Exercise



- ▶ Oxygen Consumption VO_2 and Pulmonary Ventilation VE in Exercise
- ▶ $-\text{VO}_2$ at rest for a young man is about 250 ml/min
- ▶ **-However** at Maximal efforts VO_2 and VE increase about 20-fold between the resting state and maximal intensity in well trained athletes.

	ml/min
Untrained average male	3600
Athletically trained average male	4000
Male marathon runner	5100

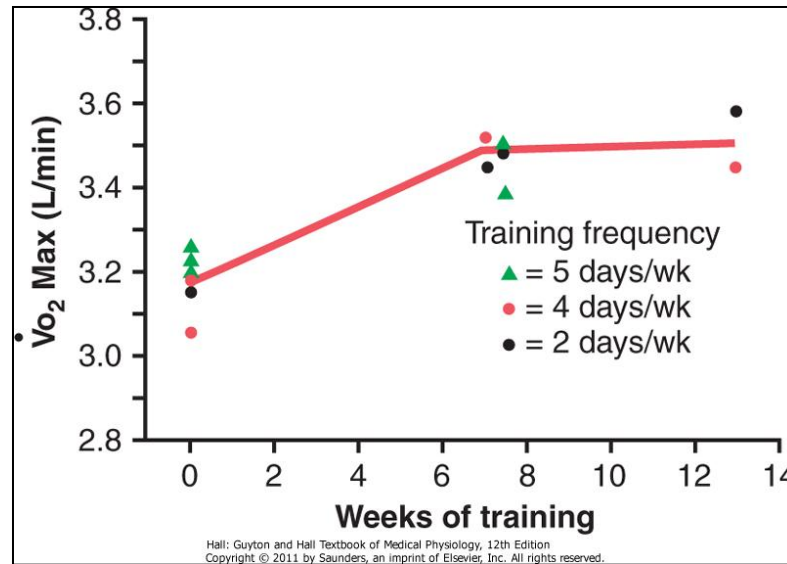


- Effect of exercise on oxygen consumption and ventilatory rate. (Redrawn from Gray JS: Pulmonary Ventilation and Its Physiological Regulation. Springfield, Ill: Charles C Thomas, 1950.)



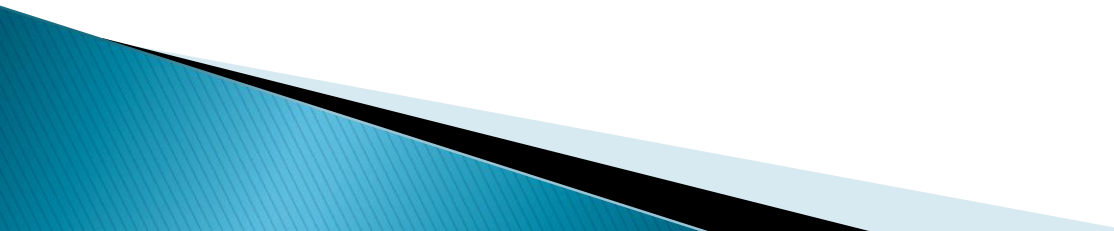
Effect of Training on Vo_2 Max;-

- ▶ Vo_2 Max :- rate of o_2 usage under maximal aerobic metabolism
- ▶ Vo_2 Max increased only about 10 percent by training, Moreover other factors can increase it:-
- ▶ 1- Chest sizes in relation to body size
- ▶ 2- stronger respiratory muscles



Increase in Vo₂ Max over a period of 7 to 13 weeks of athletic training. (Redrawn from Fox EL: Sports Physiology. Philadelphia: Saunders College Publishing, 1979.)

Cardiovascular System in Exercise

- ▶ Work Output, Oxygen Consumption, and Cardiac Output During Exercise:-
 - ▶ -all these are directly related to one another, muscle work output increases oxygen consumption, and increased oxygen consumption in turn dilates the muscle blood vessels, thus increasing venous return and cardiac output.
 - ▶ Effect of Training on Heart Hypertrophy and on Cardiac Output:
 - ▶ Training increase C.O about 40 % greater than untrained persons
 - ▶ heart chambers of marathoners enlarge about 40 percent in contrast to non trained
 - ▶ Heart size of marathoner larger than normal person , heart enlarges to increase pumping capacity in endurance types of training
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Comparison of Cardiac Function Between Marathoner and Nonathlete

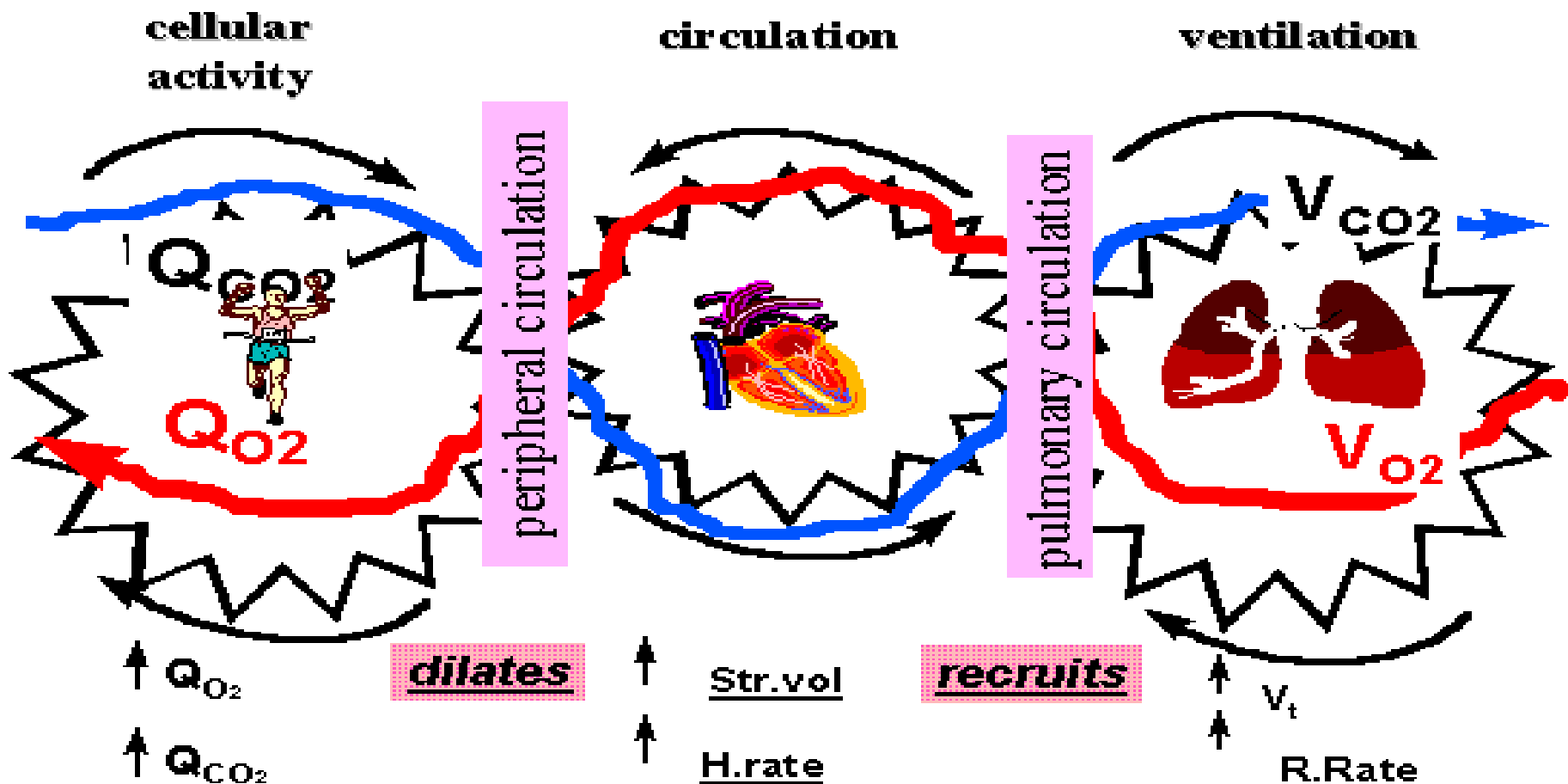
	Stroke Volume (ml)	Heart Rate (beats/min)
Resting		
Nonathlete	75	75
Marathoner	105	50
Maximum		
Nonathlete	110	195
Marathoner	162	185

[Guyton & Hall: Textbook of Medical Physiology 12E](#)

- Athletes have a lower heart rate at rest & their heart pumps more blood with a lower heart rate

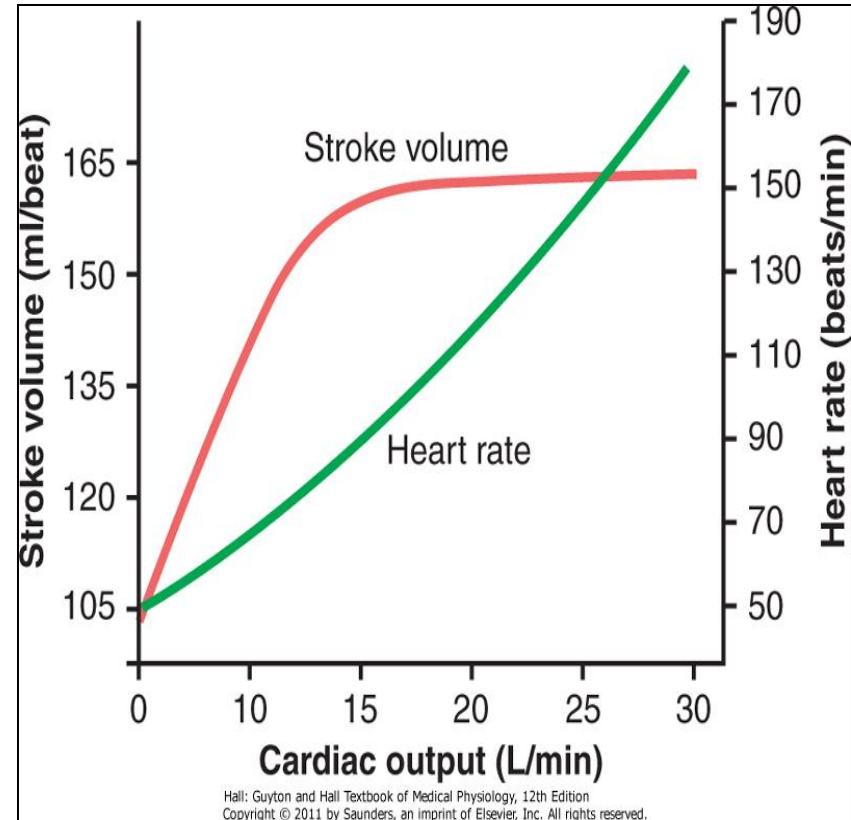
Cardiovascular System in Exercise cont...

- ▶ Role of Stroke Volume and Heart Rate in Increasing the Cardiac Output



Cardiovascular System in Exercise cont...

- The cardiac output increases from its resting level of about 5.5 L/min to 30 L/min.
- The stroke volume increases from 105 to 162 milliliters, an increase of about 50 percent in marathoners
- whereas the heart rate increases from 50 to 185 beats/min, an increase of 270 percent.
- the heart rate increase a greater proportion of the increase in cardiac output than does the increase in stroke volume



Approximate stroke volume output and heart rate at different levels of cardiac output in a marathon athlete.

Body Heat In Exercise



- ▶ Almost all the energy released by the body's metabolism converted into body heat.
- ▶ Muscle work use only 20 – 25 %.
- ▶ remainder converted into heat energy to overcome:–
 - ▶ (1) resistance to the movement of the muscles and joints,
 - ▶ (2) friction of the blood flowing through the blood vessels, and
 - ▶ (3) other effects
- ▶ –All together converts muscle contractile energy into heat.

Heatstroke



- ▶ During endurance training body temperature rises **98.6° to 102° or 103°F (37° to 40°C)**
- ▶ hot and humid conditions body temperature rise to **106° to 108°F (41° to 42°C)**
- ▶ **Consequently**, temperature destroy tissue cells mainly **(brain cells)** and symptoms appear as :
- ▶ **Body weakness, exhaustion, headache, dizziness, nausea (disgust), sweating, confusion, uncontrolled gait, collapse, and unconsciousness.**
- ▶ **And may lead to death**

Treatment of heatstroke



The most practical way :

- ▶ 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.



Thank you !

Reference book

Guyton & Hall: Textbook of Medical Physiology 12E

Thank you

