Editing file

Muscle adaptation to exercise

- Red : important
- Black : in male / female slides
- Pink : in female slides only
- Blue : in male slides only
- Green : notes
- Gray : extra
- Guyton

Objective

1-Define strength, power, and endurance of muscles.

2-Analyze the effect of athletic training on muscle structure and muscle performance.

3-Discuss the mechanism of muscle hypertrophy.

4-Contrast Fast-twitch and Slow-twitch muscle fibers.

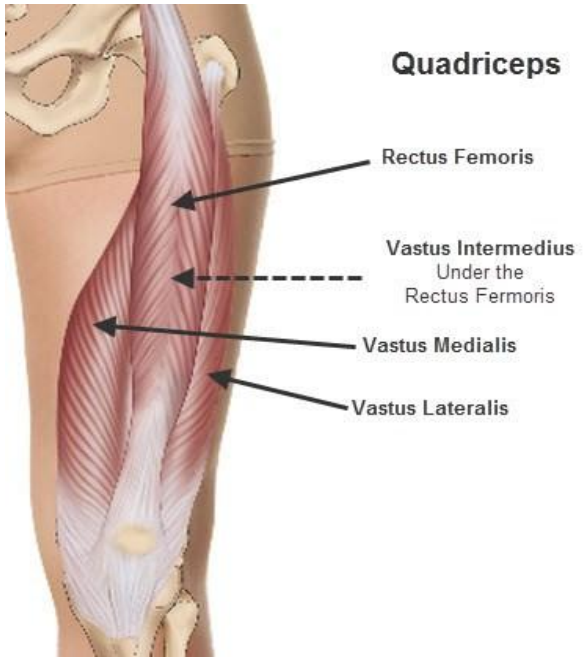
5-Explain the respiratory changes in exercise (Oxygen consumption,pulmonary ventilation and VO_2max).

6-Identify the cardiovascular changes in exercise (Work output,cardiac output, heart hypertrophy).

7-Interpret the role of stroke volume and heart rate in increasing the cardiac output.

8-Explain the body heat in exercise and the heatstroke.

Strength, Power, and Endurance of Muscles



- **Muscles strength**: Refers to the amount of force (push or pull) a muscle can produce against resistance in a single maximal effort .
- Size of the muscle influences the maximal contractile force.
- Normally 3-4 kg/cm^2 of the cross section of the muscle.

e.g. a cross-sectional area of quadriceps in world class weight lifter is 150cm^2 causes maximal contractile strength of 525 kilograms.

e.g weight lifting, digging.

Mechanical work of muscle = The force applied by the muscle x the distance over which the force is applied (kg-m).

W=FxD

Cont… Strength, Power, and Endurance of Muscles

- Strength refers to FORCE
- Work refers to FORCE & DISTANCE
- Power refers to WORK (force & distance) & TIME

Muscles Power: The amount of work the muscle performs in a period of time. It is expressed in (kg-m/min).

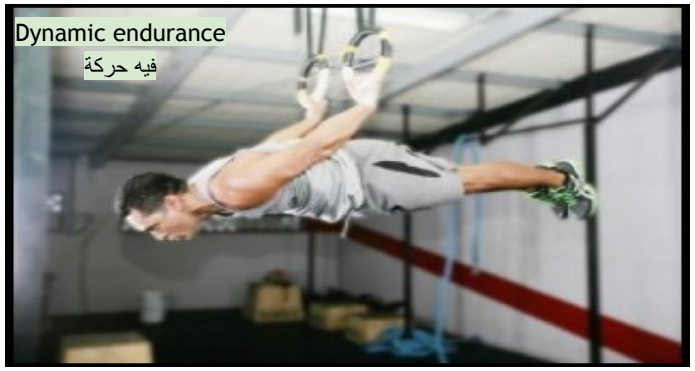
كل ما مارسنا النشاط فترة اطول كل ما القوة العضلية تبدأ تضعف وتقل

	KG-M/Min
First 8 to 10 seconds	**7000**
Next 1 minute	**4000**
Next 30 minutes	**1700**

The maximal power achievable by all muscles in the body of a highly trained athlete working together is approximately the following:

★ Muscle Endurance: The ability of the muscle to sustain repeated contractions against a resistance for a period of time.

- It depends on glycogen stored in the muscle.



★ Dynamic endurance: is defined as the muscle's ability to **contract and relax repeatedly.**

★ Static endurance: is the muscle's ability to **remain contracted** for a **long period.**

Effect of Training on Muscle and Muscle Performance

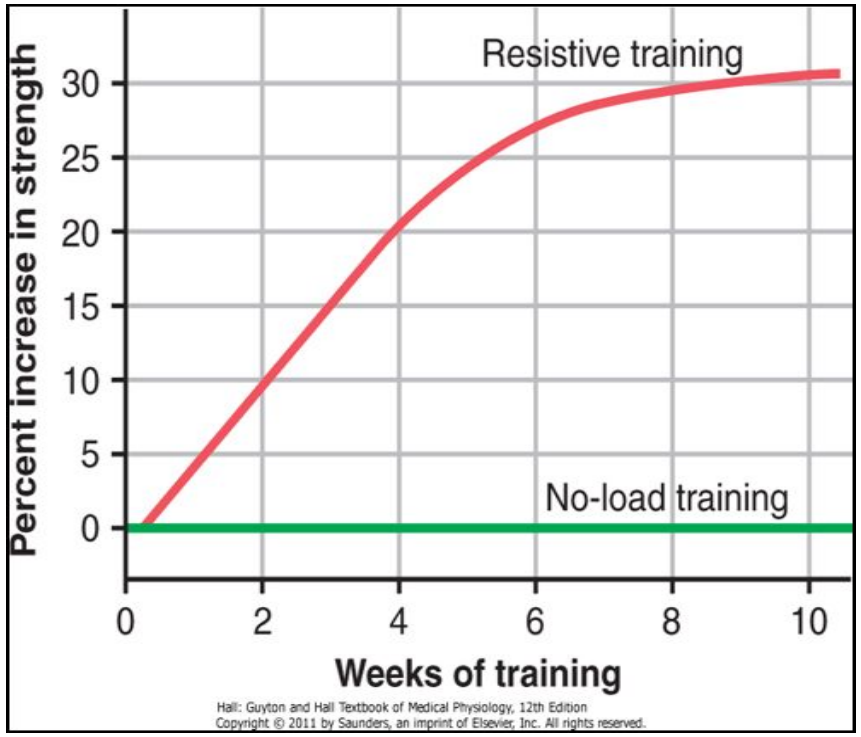
Maximal Resistance Training;

Muscles that function under **no load**, even if they are exercised for hours on end, increase little in strength. At the other extreme, muscles that **contract at more than 50% maximal force** of contraction will develop strength rapidly even if the contractions are performed only a few times each day.

e.g 6 maximal muscle contractions /3 times daily/3 days/ a week give approximately optimal increase in muscle strength, without producing chronic muscle fatigue.

However Multiple weeks of increased muscles function under **no load** will cause little increase in strength.

Resistance training;
Physical exercise, builds the strength. Weight lifting



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

- المتدرب الأحمر قلنا له يسوي تمرين ويزيد المقاومة ، فقوته العضيلة زادت
- المتدرب الأخضر قلنا له يسوي تمرين بدون ما يزيد المقاومة، فقوته العضلية ما تغيرت

Muscle Hypertrophy

(Guyton)

Along with this increase in strength is an approximately equal percentage increase in muscle mass. (muscle hypertrophy)

➔ With training **muscles hypertrophied** 30-60 %, Due to ⬆ diameter of the muscle fibers Rather than increased number of fibers.

➔ *However*, a very few greatly enlarged muscle fibers are believed to split down forming entirely new fibers, thus increasing number of fibers slightly.

Changes in the hypertrophied muscle fiber:

A. ⬆ myofibrils numbers. (not muscle fibers)
   120 % ⬆ in mitochondrial enzymes
B. ⬆ in Phosphagen metabolic system components including ATP and phosphocreatine.
C. 50 % ⬆ in stored glycogen.
D. 75 -100 % ⬆ in stored triglycerides.
E. Increased both the aerobic & anaerobic metabolisms.

➔ **<u>Therefore increase efficiency of the oxidative metabolic system increases by 45 %.</u>**

الرياضي اذا اكل اكله دسمة وتحتوي على دهون كثير راح يهضمها ويتخلص من الدهون بشكل اسرع من الغير رياضي

بعد التمرين يزداد عدد WBC "كأن فيه "inflammation ، بسبب وجود Micro internal bleeding
لذلك بعد التمرين لازم يكون فيه يوم break علشان ال Healing.
بعد ال Healing راح يزداد عدد وحجم ال muscle fibers.

Fast-Twitch Muscle Fibers

White muscle fiber

Achieves maximal power in very short periods of time. Adapted for forceful and rapid contraction.

e.g. gastrocnemius muscle used for jumping. (anaerobic metabolism).

VS

Slow Twitch Muscle Fibers

Red muscle fiber

Provide endurance, prolonged strength of contraction minutes to hours. Is organized for generation of aerobic energy.

E.g of Slow-twitch muscle adapted for prolonged muscle activity is soleus muscle in the lower leg muscle for standing. (aerobic metabolism)

(Guyton)

Hereditary Differences Among Athletes for Fast-Twitch Versus Slow-Twitch Muscle Fibers explains why Some people have considerably more fast-twitch than slow-twitch fibers, and others have more slow-twitch fibers; this factor could determine to some extent the athletic capabilities of different individuals.

Unfortunately, Athletic training has not been shown to change the relative proportions of those types of fibers.

★ In summary

fast-twitch fibers can deliver extreme amounts of power for a few seconds to a minute or so.

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

Helpful video

ريلاكس سهلة بس كلام كثير

Respiration In Exercise

Oxygen Consumption (VO_2) and Pulmonary Ventilation (VE) in Exercise.

VO_2 at rest is about 250 ml/min. Ventilation كل ما يزيد احتياجي للاكسجين يزيد

However at Maximal efforts can be **as follows:**

VO_2 and VE increase about 20-fold between the resting state and maximal intensity.

Effect of Training on VO_2 Max

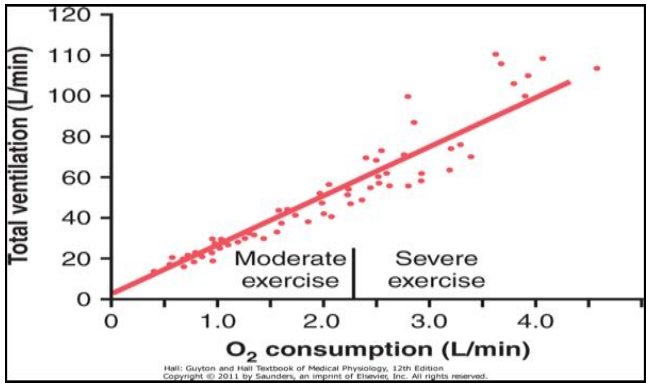
VO_2 Max: The rate of oxygen usage under maximal aerobic metabolism is VO_2 Max.

In the below study VO_2 Max increased only about 10% by training. كأن شغله VO_2 max; evaluating aerobic system

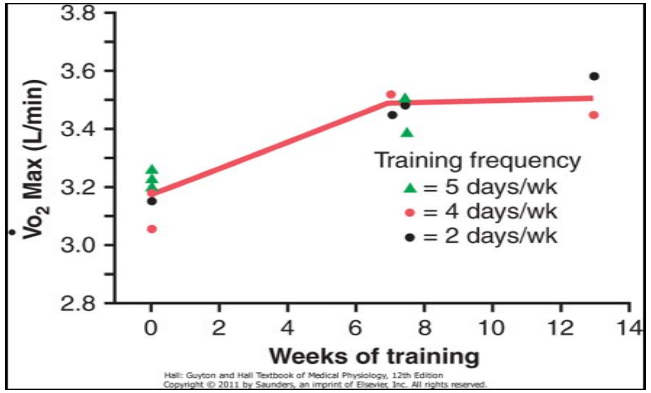
Moreover other factors such as:

- chest sizes in relation to body size.
- respiratory muscles contraction can also increase VO2 Max.

	Ml/Min
untrained average male	3600
athletically trained average male	4000
male marathon runner	5100



Effect of exercise on oxygen consumption and ventilatory rate.



Increase in VO_2 Max over a period of 7 to 13 weeks of athletic training.

كل ما زاد عدد مرات التدريب بالاسبوع كل ما كان افضل

المتدرب الاسود اقلهم مرات تدريب واستهلاك O_2 عنده أعلى من البقية

O_2 consumption: The amount of oxygen needed to meet the metabolic needs of the tissues.

Pulmonary ventilation: refers to the total exchange of air between the lungs and the ambient air (New air enter respiratory passage.)

Cardiovascular System in Exercise

- Work Output, Oxygen Consumption, and Cardiac OutPut (C.O.P) During Exercise are directly related to one another.

HOW?

- Muscle work ⬆ oxygen consumption ➡ dilates the muscle blood vessels, thus ⬆ venous return and C.O.P .

عملية مترابطة، مثل لما تتدرب انت تحتاج استهلاك اكبر لل O_2 فبناء على هذا راح تتوسع vessel عندك
وبالتالي عودة الدم راح تكون اسرع للقلب وراح يزداد النبض
So the C.O.P increase

CO = HR X SV

Cardiac output = heart rate X stroke volume

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

Effect of Training on Heart Hypertrophy and C.O.P:

- Training increases C.O.P about 40 % than in untrained persons.
- Heart **chambers** of marathoners **enlarge** about 40% in contrast to non trained, along with that increase is the **mass** of the heart by also 40% or more .
- Heart **size** of marathoner larger than normal person.

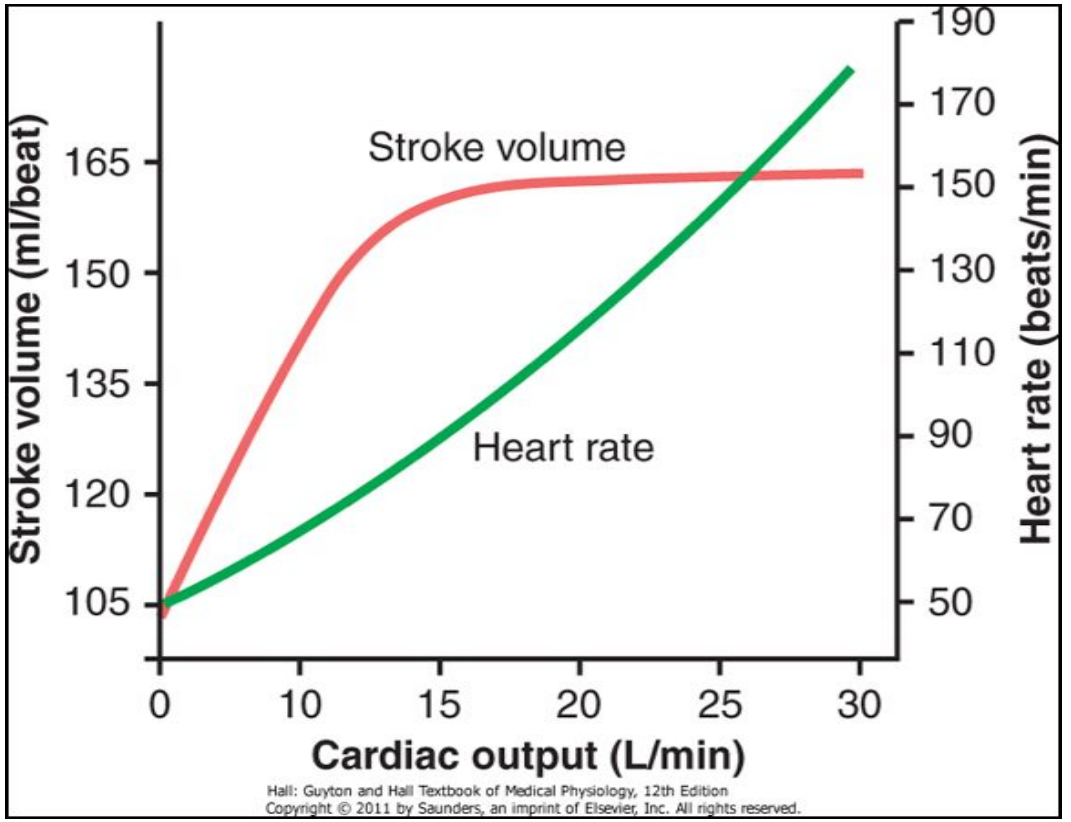
Stroke volume: حجم دفع الدم بالقلب في الدفعة الواحدة

Cont.. Cardiovascular System in Exercise

In Marathon runner the cardiac output increases from its resting level of about 5.5 L/min to 30 L/min.

	Before	After	Change
Stroke volume (Ml/beat)	105	162	50%
Heart rate (Beats/min)	50	185	270%

- The heart rate increase a greater proportion of the increase in cardiac output than does the increase in stroke volume.



Stroke volume is restricted > depend on chambers

Body Heat In Exercise

- Almost all the energy released by the body's metabolism of nutrients is converted into body heat. To cool down
- Working muscle use only 20-25 %.

- A small portion of the energy is used for

I. overcoming viscous resistance to the movement of the muscles and joints
II. overcoming the friction of the blood flowing through the blood vessels
III. other, similar effects —all of which convert the muscle contractile energy into heat.

- Almost all the energy that does go into creating muscle work still becomes body heat.

★ **What will happen if sweating mechanism cannot eliminate the heat?**

An intolerable and even lethal condition called heat-stroke can easily develop in the athlete.
(From guyton)

(Guyton)

The person has stopped exercising, the temperature does not easily decrease by itself in the heat-stroke

Because:

1. temperature-regulating mechanism often fails .
2. very high body temperature doubles the rates of all intracellular chemical reactions due to increase of K.E, thus liberating still more heat.

Heatstroke

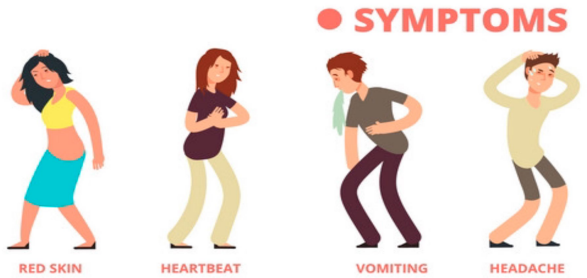
- ➔ During endurance training body temperature rises from (37° to 40°C)
- ➔ In hot and humid conditions body temperature rise up to (41° to 42°C)
- ➔ High temperature is destructive to tissue cells mainly (**brain cells**).

Symptoms: Body weakness, exhaustion, headache, dizziness, nausea (disgust), sweating, confusion, uncontrolled gait, collapse, and unconsciousness ➡ may lead to death.

Treatment of heatstroke

1. Remove all clothing
2. Maintain a spray of cool water on all surfaces of the body
   (or continually sponge the body.)
3. 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.



Quiz

SAQ

Q1- What will happen if sweating mechanism cannot eliminate the heat ?

Q2- Muscles that function under no load will cause ?

Q3- what causes the maintains the temperature high in heat- stroke even after stopping exercise?

Answers

SAQ1- heat-stroke.

SAQ2- little increase in strength

SAQ3- temperature-regulating mechanism often fails and the very high body temperature doubles the rates of all intracellular chemical reactions due to increase of K.E, thus liberating still more heat.

1) The amount of work the muscle performs in a period of time is definition of?		2) example of physical activity builds strength of the muscle ?	
A.	Muscle strength	A.	Running
B.	Muscle static endurance	B.	Walking
C.	Muscle power	C.	Dancing
D.	Muscle dynamic endurance	D.	weight lifting
3) heat stroke temperature		4) cardiac output equation	
A.	34	A.	HR X SV
B.	40	B.	HR X VE
C.	20	C.	VO_2 X SV
D.	36	D.	VO_2 X HR

Answers key: 1) C 2) D 3) B 4) A

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Thank you

@physiology438

Editing file

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Our team members and leaders

PHYSIOLOGY MSK BLOCK DONE 👏

We hope that you loved our team work and physiology in this block.

ALWAYS REMEMBER:🧠

“Physiology is the <u>stepchild</u> of medicine.

That is why Cinderella often turns out the queen.”

- by Martin H. Fischer